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Research Application Summary

Influence of Niger plant *(Guizotia abyssinica* l.) on growth and development of common beans (*Phaseolus vulgaris*)

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Abstract

Plants affect other plants growing in their vicinity either positively or negatively by producing exudates known as secondary metabolites. These secondary metabolites, also known as allelochemicals, can be harnessed and utilized in controlling the growth of weeds, among other uses. 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 *(Guizotia abyssinica*) has been observed to have allelopathic effects on certain weeds. Studies have been done on the effect of allelochemicals on weeds but little on crops that coexist with the weeds. Treatments included weedy check (no weed control measure), weed free, Niger plant intercrop and all weeds except Niger plant. Three varieties of beans (Rosecoco, Mwitemania and Mwezi Mbili) were used. The experiment was a 3 x 4 factorial laid out in Randomized Complete Block Design (RCBD) with three replicates. Data were collected on stand count at two weeks, plant height at 50% flowering, number of pods per plant, number of seeds per plant and stand count at harvesting. Data analysis was done by ANOVA in Genstat and means separated using Duncan's Multiple Range Test (DMRT). Results showed that Niger plant positively influenced the growth and development of beans. Niger plant can therefore safely be intercropped with beans without compromising its growth and development. Further research should be carried out on the influence of Niger plant on bean yield.

Key words: Allelochemicals, exudates, *Guizotia abyssinica,* interaction, intercrop, metabolites, weeds

Résumé

Les plantes affectent les autres plantes environnantes de manière positive ou négative en produisant des exsudats appelés métabolites secondaires. Ces métabolites secondaires, également appelés allélo-chimiques, peuvent être exploités et utilisés pour contrôler la croissance des mauvaises herbes, parmi tant d'autres utilisations. La demande mondiale actuelle de technologies de gestion des mauvaises herbes moins chères et plus respectueuses de l'environnement a motivé un certain nombre d'études sur l'interaction allélo-pathique entre les cultures et les mauvaises herbes. On a observé que la plante du Niger (*Guizotia abyssinica*) avait des effets allélo-pathiques sur certaines mauvaises herbes. Des études ont été faites sur l'effet des allélo-chimiques sur les mauvaises herbes, mais peu sur les cultures qui coexistent avec les mauvaises herbes. Les traitements comprenaient un contrôle des mauvaises herbes (sans mesure de contrôle des mauvaises herbes), sans mauvaises herbes, des cultures intercalaires de plantes du Niger et toutes les mauvaises herbes à l'exception des plantes du Niger. Trois variétés de haricots (Rosecoco, Mwitemania et Mwezi Mbili) ont été utilisées. L'expérience était une factorielle 3 x 4 disposée en conception de blocs complets randomisés (CBCR) avec trois répétitions. Les données ont été recueillies sur le nombre de peuplements à deux semaines, la hauteur des plantes à 50% de floraison, le nombre de gousses par plante, le nombre de graines par plante et le nombre de peuplements à la récolte. L'analyse des données a été effectuée par ANOVA dans le logiciel Genstat et les moyennes ont été séparées à l'aide du test de plage multiple de Duncan. Les résultats ont montré que la plante du Niger a influencé positivement la croissance et le développement des haricots. La plante du Niger peut donc être cultivée en toute sécurité avec les haricots sans compromettre sa croissance et son développement. De recherches supplémentaires devraient être menées sur l'influence de la plante du Niger sur le rendement des haricots.

Mots-clés: Allélo-chimiques, exsudats, *Guizotia abyssinica*, interaction, cultures intercalaires, métabolites, mauvaises herbes

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 labour 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 (Vissoh *et al.,* 2004). Crops co-existence 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 and Rizzardi, 2013).

It has been observed that in areas where Niger plant grow, there are fewer weeds in the succeeding season. This has led to the hypothesis that Niger plant interacts with weeds negatively to cause a reduction in their number. Such an observation points out to a potential use of Niger plant as a bio-herbicide. However, there is no data available on the effect of Niger plant on crops. 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 that needs urgent intervention so as to attain high yields and achieve food security. As a result of the increasing awareness of the adverse toxicological effects of synthetic herbicides, the current trend in weed management is to reduce heavy reliance on synthetic herbicides and to move towards low input sustainable agriculture (LISA) (Andrew *et al.,* 2015). 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 and Callaway, 2003).

Even with the ongoing advances in research on allelopathy, the knowledge gap is still vast. The aim of this experiment was to evaluate the allelopathic effect of Niger plant on bean growth and development.

Materials and methods

Field experiments were conducted at the University of Eldoret Research farm located in Western Kenya for two seasons from September – December 2017 and December – February, 2018.

The experiment involved growing three varieties of beans as the test crop: Rosecoco (V1), Mwitemania (V2) and Mwezi Mbili (V3) under four different weed regimes. The weed regimes included a weedy treatment (W), 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 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, distribution in the plots 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. In the field layout, these were represented as T1, T2, T3 and T4, respectively. The choice of the study site was guided by presence of Niger plant weeds as determined in the earlier cropping season.

Experimental design and field lay out. The experimental design for the experiment was a 3 x 4 factorial arranged in a Randomized Complete Block Design (RCBD) and replicated three times. Each plot measured 1.05 m x 0.7 m, separated by a 0.5 m path. The beans were spaced at 15 x 10 cm giving a total of 49 plants per plot separated by a 0.5 m path.

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 shown in Fig. 1 above, the field was marked ready for planting. Three varieties 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.

Data were collected on the following parameters: Stand count at two weeks post emergence; plant height at 50% flowering; number of pods per plant; stand count at harvesting; and number of seeds per plant. Data collected were subjected to Analysis of Variance (ANOVA) using Genstat version 14. Mean separation was done by Duncan's Multiple Range Test (DMRT) at 0.05 level of probability.

Results and discussion

There was a significant weed regime effect for common bean stand count two weeks after planting (Table 1). Niger plant intercropped and weed free treatments had the highest means which were equal to one another in season 2. Stand count at two weeks is mostly a reflection of germination percentage. High stand count at two weeks similar with the weed free control in season 2 suggests that Niger plant does not negatively affect the germination of beans. Whereas some crops are negatively affected by exudates from other plants, in some, the effects are favourable and the plants are said to exhibit positive allelopathy. Results from a study by Hussain *et al.* (2007) on allelopathic effect on wheat showed a promotion in wheat height though it was reduced in other crops. The results of this study agree with these earlier findings. This finding shows that allelopathic effects are species specific and at times variety specific. This specificity in reaction can be the result of genetic differences and how well the plant is able to adapt to the stress it is subjected to.

On plant height at 50% flowering, there were significant differences ($P < 0.05$) in both weed free treatment and in all weeds except Niger plant treatment in both season 1 and season 2. Varietal differences were significant only in season 2 where variety 3 (Mwezi Mbili) had an average height of 45 cm. Both variety 1 (Rosecoco) and variety 2 (Mwitemania) had height means of 32 cm. Allelochemicals can alter the contents of plant growth regulators or induce imbalances in various phytohormones, which inhibits the growth and development of plants, for example, with respect to seed germination and seedling growth. Most phenolic allelochemicals can stimulate indole acetic acid (IAA) oxidase activity and inhibit the reaction of POD with IAA, bound GA or IAA to influence endogenous hormone levels (Yang *et al.,* 2005). However, results of this study show the contrary as height of beans in the vicinity of Niger plants were not affected.

There were significant differences ($P<0.05$) in the number of pods per plant in weed free and Niger plant intercropped treatments. In both season 1 and 2, Niger plant treatment had the highest means at 9 and 11 pods per plant respectively. Weed free treatment recorded the same number of pods in both season 1 and season 2 (7 pods per plant). There were also significant differences in bean varieties used in both seasons. Weedy plots recorded the lowest number of pods at 2 and 4 seeds in season 1 and season 2, respectively.

There were significant differences between pod number of different varieties in both seasons. Variety 3 (Mwezi Mbili) had the highest mean at 7 pods per plant. High mean number of pods per plant in variety 3 can be attributed to the morphology of the bean variety. Variety 3 grows long apical tendrils that support themselves on other plants in close proximity to them and due to this they have a larger surface to grow pods. Additionally, due to the tendrils, this variety was able to compete effectively with weeds for sunlight.

The highest number of seeds per pod was counted in Niger plant intercropped treatments in season 2. In both seasons, there were significant differences brought about by different weed regimes. Some allelochemicals produced by plants act to stimulate pod and seed formation. In a study on sorghum allelopathy, Tesfamariam *et al.* (2014) found out that sorgoleone, a sorghum

Table 1. Effect of bean variety and Niger plant on selected common bean performance parameters

Season	Variety	Stand count at 2 weeks	Height (cm) at 50% flowering	Number of pods per plant	No. of seeds per pod	Stand count at harvesting
	1	42a	30a	4a	3a	18a
	2	43a	30a	6b	3a	22b
	3	43a	31a	7c	3a	19a
1	F. prob.	0.866	0.378	0.001	0.384	0.098
	SE	1.515	2.467	1.599	0.726	3.965
	SED	0.619	1.007	0.653	0.297	1.619
	CV	3.6	8.1	29.4	27.0	20.1
	1	25a	32a	5a	5a	25a
	2	28a	32a	8b	5a	28a
	3	27a	45b	8b	5a	27a
2	F. prob.	0.288	0.001	0.001	0.963	0.288
	SE	3.795	3.796	1.623	1.480	3.795
	SED	1.549	1.550	0.663	0.604	1.549
	CV	14.4	10.5	22.3	30.1	14.4
Season	Weed regime	Stand count at 2 weeks	Height (cm) at 50% flowering	Number of pods per plant	No. of seeds per pod	Stand count at harvesting
	1	43a	21a	3a	2a	10a
	2	42a	39b	9c	4c	34c
	3	43a	39b	7b	3b	24b
	4	42a	22a	3a	2a	11a
1	F. prob.	0.365	0.001	0.001	0.001	0.001
	SE	1.515	2.467	1.599	0.726	3.965
	SED	0.714	1.007	0.754	0.342	1.869
	CV	3.6	8.1	29.4	27.0	20.1
	1	13a	32a	5a	4a	13a
	2	39d	40b	11c	6b	40d
	3	33c	40b	7b	5ab	33c
	4	21b	33a	5a	4a	21b
2	F. prob.	0.001	0.001	0.001	0.015	0.001
	SE	3.795	3.796	1.623	1.480	3.795
	SED	1.789	1.789	0.765	0.698	1.789
	CV	14.4	10.5	22.3	30.1	14.4

allelochemical, influenced the biogeochemical cycles of nutrients, by reducing the activity of Nitrosomonas bacteria and consequently increased the ammonium content in the soil leading to higher crop yields. This finding agrees with that of the present experiment. Another likely reason for high number of seeds per pod in Niger plant and weed free treatments is the suppression or lack of weeds, which minimized light, space and nutrient competition between beans and weeds.

On stand count at harvesting, results of weedy treatment and those with all weeds except Niger plant were not significantly different ($P < 0.05$) from one another. However, there were significant differences between Niger plant and weed free treatments. There were significant differences in varieties too. This result can be due to the influence that Niger plant had on the soil and the environment that enabled beans to thrive.

Conclusion

From the study, Niger plant exhibited positive allelopathy on bean growth and development therefore it can be safely intercropped with beans without compromising on their growth and development.

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