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Research Article

Allelopathic potential of differential concentrations of rice husk residues: Implications on the growth and yield of cowpea (Vigna unguiculata L.)

Abstract

The allelopathic effect of different concentrations of rice husk residues (*Vigna unguiculata* L.) was investigated with a view to determining its effect on the growth and field of four cowpea varieties. The results indicated that the extracts at 40g brought about considerable inhibition in the morphological parameters studied including plant height, stem girth, number of branches, number of leaves, and leaf area irrespective of the stages of development than the extracts at 40g concentration. The extracts had significant effect on the plant height of variety 4 (NGB/06/0055) at 40g relative to the control. This was also observed for the stem girth and number of branches of cowpea in variety 3 (NGB/06/1642) at 40g concentration thereby indicating that the degrees of inhibition were concentration dependent. It was apparent that rice husk residues at 40g concentration had more inhibitory effect on the yield of cowpea than at 20g concentration level. Variety 4 had the highest number of seeds per plant (147) while the least was recorded in variety 3 (44) relative to the control.

Introduction

The interference of weeds in agricultural field greatly reduce crop yield, thereby hindering the possibility of achieving the desired goal of food seurity and sustainability. Allelopathy could simply be described as a biological phenomenom through which an organism poduces one or more biochemical substances (allelochemicals) that influences the germination, growth, survival and reproduction of other organism [1]. These biochemicals which could either be stimulatory or inhibitory are released by leaching, root exudation, volatilization, residue decomposition and other processes in both natural and agricultural systems [2]. Allelopathic compounds may regulate plant growth and developmental processes involving metabolism, as well as protein, nucleic acid synthesis [3]. The biomolecules (allelochemicals) are biosynthesized secondary metabolites in plants such as tannins, trepnoids, coumarins and phenolics substances [4]. Allelochemicals are present in virtually all plants parts including leaves, stem, flower, fruits, seeds, pollen grains [5] from where they are released into the environment through decomposition [6], which are capable of suppressing the growth of other plants. These allelochemicals may be used as natural pesticide at high concentration [7]. Action of these compounds is concentration dependent as these inhibit the plant growth at high concentration and promotes it at low concentration [8]. Application of allelochemicals at low concentration to crops can be a cost effective and efficient way to promote growth and to enhance crop productivity [9]. In addition to water extract, allelopathy can play effective role in controlling weeds through soil incorporation of allelopathic crop residues. [10,11] Rice husk or hull is the natural sheath or protective cover, which forms the cover of rice grains during their growth. Rice husk represent about 20% by weight of rice harvested, about 80% by weight of the raw husk is made of organic compound. During refining processes, the husk are removed from the grains, it is not useful to feed either human or cattle. Incorporation of rice husk into the soil mixture found to have affected many crops [12]. Soil organic matter content is gradually declining due to high cropping intensity which causes quick decomposition of organic matter. Use of rice husk as an organic fertilizer may play an important or vital role not only in improving the soil fertility but also in improving the plant nutrients [11]. Cowpea (*Vigna unguiculata* L.) is a popular leguminous stable food in Nigeria [13]. It is cultivated and used fresh in derived savannah and rainforest belts thus it is available throughout the year either as vegetable or as a pulse [14,5,16] maintained that cowpea contains protein, 17.4–31.7%; fat, 1.00–3.03%; carbohydrates, 35.7–65.7%; dietary fiber (including insoluble fiber), 19.5–35.6% (1.7–16.6%); and mineral content 2.6–4.6%.

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Materials and Methods

Experimental site

The experiment was carried out at the Screen house of Department of Plant Science and Biotechnology, Adekunle Ajasin University, Akungba Akoko, Ondo State.

Seed collection / rice husk collection

Seeds of four varieties of Cowpea (*VignaunguiculataL. Walp*) which includes (NGB/SA/07/113, NGB01643, NGB01642, NGB/06/0055) were collected from the seed bank of National Centre for Genetic Resource and Biotechnology, Ibadan,OyoState,Nigeria.A Rice husk residue wasobtained from the rice rmill at Igbemo Ekiti, Ekiti state.

Soil collection

Top soil to the depth of 10cm was collected from the biological garden and filled into thirty six plastic pots of depth (8cm by 24cm) .The plastic pots was perforated at the bottom to enhance drainage during the course of the experiment.

Preparation of rice husk treatment

Portion of 0g, 20g, 40g was measured from the rice husk residue using a sensitive weighing balance and was mixed thoroughly with the soil

Experimental design

The experimental design is made up of three (3) treatments which include T1 (Top soil + water) control, T2 (Top soil+ Rice husk at 20g), T3 (Top soil + Rice husk at 40g). Each treatment was replicated three times and arranged in a Randomized Completely Block Design.

Morphological parameters

Measurement of Leaf Area (LA): LA=L W 2.325 (Cowpea) [17], The unit of LA is cm^2, L and W are the leaf length and width respectively while 2.325 is the correction factor of cowpea.

Measurement of leaf area ratio: LAR accounts for the total surface area used for assimilation power unit of plant biomass present. The unit is cm^2g-1, Ws is plant dry weight.

Number of leaves per plant: Leaf number was determined by counting the total number of leaves of each of the plant.

Measurement of stem Girth: Stem girth was measured using a digital venier caliper at 10cm from the base of the stem.

Measurement of plant height: Plant height was determined using a meter rule from the soil level to the apical bud.

Number of branches per plants: The numbers of branches is determined by counting the total number of branches of each plant

Yield component

Number of pods per plant: The number of pods per plant was determined manually by counting.

Number of pods per peduncle: The numbers of pods per peduncle was done manually by counting

Numbers of seed per pod: The numbers of seed per pod was determined manually by counting the seeds per pod.

Number of seeds per plant: The numbers of seed per plant is determined manually by counting.

Pod length: These were done manually by the use of a meter rule.

Peduncle length: This was measured with the use of meter rule.

Numbers of seed per plant: These were determined manually by counting.

Statistical analysis

Data were statistically analyzed using Statistical Analysis System (SAS) version 8.1 (SAS Institute, 2008). The treatment means were compared using a revised Duncan Multiple Range Test at the 0.05 level of Significance.

Proximate Analysis: The proximate composition was determined using established procedures [18].

Result

The allelopathic effect of rice husk residues on the plant height and stem girth of four varieties of cowpea (NGB/SA/07/113, NGB01643, NGB01642, NGB/06/0055) at various developmental stages is presented in table 1. There was a significant difference on the plant height of NGB01643 at 20g concentration and was observed to be the highest as against NGB07/11 which was observed to be the lowest (10.64cm) at 40g rice husk concentration during the germination stage. There were variations in the plant height of the cowpea cultivars during the vegetative and reproductive stages. NGB0055 was observed to have the highest plant height (27.72cm) under the control treatment during the vegetative stage relative to other levels of concentration. However, NGB01643 recorded the highest plant height during the reproductive stage (40.50cm) at 20g rice husk concentration.

There were variations in the stem girth of cowpea varieties under the various treatments and developmental stages (table 1). At the germination stage, NGb01642 recorded the highest stem girth (2.74mm) at 20g rice husk concentration. However, at the vegetative stage, stem girth of 3.98mm was recorded in NGB01642 at this level of treatment. The reproductive stage follows similar trend as the stem girth of 6.84mm was observed in NGB01643 at 20g rice husk concentration relative to the control and other levels of treatment.

Table 2 shows the allelopathic effect of rice husk residue on the number of branches and leaf area of cowpea at the germination, vegetative and reproductive stage. There were significant differences on the number of branches of cowpea

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Table 1: Allelopathic effect of rice husk residue on the plant height and stem girth of cowpea at the germination, vegetative and reproductive stages.

	Plant height (cm) Germination				Relati Plant height (cm) Vegetative				Plant height (cm) Reproductive			
TRT / VAR	NGB 07/11	NGB 01643	NGB 01642	NGB 0055	NGB 07/11	NGB 01643	NGB 01642	NGB 0055	NGB 07/113	NGB 01643	NGB 01642	NGB 0055
0	12.42a	18.94b	14.50b	19.64a	15.41c	26.60a	18.40c	27.72a	25.71b	35.80c	30.72a	28.41a
20	13.60b	20.40a	16.58a	16.56b	18.50b	20.42c	21.70b	18.40b	28.42a	40.50a	30.75a	25.60b
40 Mean	10.64c	16.40c	15.65a	16.64b	19.85a	22.54b	23.56a	18.45b	24.56c	38.68b	28.96b	22.82c
LSD	**1.42**	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42
TRT / VAR		**Stem girth**			**Stem girth**					**Stem girth**		
0	1.60b	1.64b	1.65c	1.68a	3.20b	3.40b	2.84b	3.56a	6.42a	6.67b	4.80b	6.42a
20	2.40a.	1.98a	2.74a	1.80b	3.56a	3.56a	3.98a	2.80b	5.21b	6.84a	5.80a	4.98b
40	1.40c	1.54b	2.25b	1.80b	2.72c	3.20c	2.80b	2.40c	4.20c	4.80c	4.01c	4.81c
LSD	**1.68**	**1.68**	**1.68**	**1.68**	**1.68**	**1.68**	**1.68**	**1.68**	**1.68**	**1.68**	**1.68**	**1.68**

Means with the same letter in the columns do not differ significantly (P<0.05).

Table 2: Allelopathic effect of rice husk residue on the number of branches and leaf area of cowpea at the germination, vegetative and reproductive stages.

	No of branches Germination				No of branches Vegetative				No of branches Reproductive			
TRT / VAR	NGB 07/11	NGB 01643	NGB 01642	NGB 0055	NGB 07/11	NGB 01643	NGB 01642	NGB 0055	NGB 07/113	NGB 01643	NGB 01642	NGB 0055
0	1.80a	1.74a	1.56a	1.84a	4.01c	5.20c	4.82c	4.65c	5.20c	6.40c	5.84c	5.70c
20	1.76a	1.65b	1.45b	1.75b	6.24b	8.41b	5.96b	6.32b	6.40b	9.56b	7.20b	7.43b
40	1.67b	1.60b	1.42b	1.60c	8.28a	8.50a	9.71a	9.71a	8.60a	9.20a	9.80a	11.50a
LSD	**1.12**	**1.12**	**1.12**	**1.12**	**1.12**	**1.12**	**1.12**	**1.12**	**1.12**	**1.12**	**1.12**	**1.12**
TRT / VAR		**Leaf area**			**Leaf area**					**Leaf area**		
0	25.42c 25.60c		26.10c 27.41c		54.72c 59.92c		60.45c 56.10c		42.71c	66.41c	65.10c	59.71c
20	32.76b50.16a	34.84b	38.40b	41.72b	68.45b	64.32b	66.46b	70.17b	60.40b	80.42b	82.52b	76.40b
40	**7.65**	47.24a	64.71a	54.50a	84.56a	89.40a	76.52a	80.56a	68.71a	96.48a	98.76a	84.76a
LSD		**7.65**	**7.65**	**7.65**	**7.65**	**7.65**	**7.65**	**7.65**	**7.65**	**7.65**	**7.65**	**7.65**

Means with the same letter in the column do not differ significantly (P<0.05).

varieties at various developmental stages. The number of branches of the cowpea varieties also increased along the stages of development irrespective of the treatments under consideration. Hence, NGB0055 was observed to have the highest number of branches (11.50) at 40g rice husk concentration during the reproductive stage while the vegetative stage recorded 9.71with NGB01642 and NGB0055 at 40g rice husk concentration relative to the control.

There were significant differences in the leaf area of cowpea at various developmental stages independent of the treatment (table 2). All the cowpea varieties recorded the highest leaf area at 40g rice husk concentration and at every stage of development. However, there was a steady decline in the leaf area of NGB07/11 during the reproductive stage (42.71) as against 54.72 that were recorded during the vegetative stage. Effect of control treatment on some yield components of cowpea is shown in table 3. There were no significant differences on the number of seeds/pod (SP), pod length (PL), length of peduncle (LP) and days to flowering (DFF) in NGB01642 and NGB0055. Also, there were no significant differences on the number of pods/plant, number of seeds/plant (NSP) and number of pods/peduncle in NGB07/11 and NGB01643. The highest number of days to flowering was recorded in NGB0055 while the least number of seeds/pod was also observed in NGB01642 and NGB0055.

Table 4 shows the allelopathic effect of rice husk (20g) on some yield components of cowpea. There was no significant difference on the allelopathic effect of rice husk on the yield components investigated. The highest number of days to flowering was recorded in NGB01643 and NGB01642 (71.0) respectively while the least length of peduncle of 12.66 number of pods/peduncle of 3.00 was noticeable in NGB01642.

Allelopathic effect of rice husk (40g) on some yield components of cowpea is presented in table 5. NGB0055 recorded the highest number of pods/plant (21.66) and also the highest number of days to flowering (70.33). However, NGB07/11 recorded the least number of pods/plant (8.33) and number of days to flowering (44.66). The highest number of seeds/plant (147) was also observed in NGB0055. There were no significant differences on the allelopathic effect of rice husk on some of the yield components of cowpea studied.

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Table 3: Effect of control treatment on some yield components of cowpea.

Treatment 1 (Control)							
Varieties	**NPP**	**PL**	**NSP**	**SP**	**PPD**	**LP**	**DFF**
NGB07/11	8.33[a]	17.23[a]	55.33[a]	7.00[a]	3.66[a]	11.83[a]	68.33[a]
NGB01643	10.33[a]	16.38a	68.66[a]	6.66[a]	5.00[a]	9.66[b]	63.66[a]
NGB01642	5.00[b]	15.31[a]	30.66[b]	6.00[a]	2.00[b]	12.33[a]	63.33[a]
NGB0055	13.66[a]	15.83[a]	82.00[a]	6.00[a]	6.66[a]	16.33[a]	68.00[a]
LSD	**7.37**	**1.52**	**20.38**	**1.15**	**3.88**	**3.85**	**13. 64**

Means with the same letter in the column do not differ significantly (P<0.05).

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Keys

NPP-Number of pods/plant; **PL**-Pod length; **NSP**-Number of seeds/plant; **SP**-Number of seeds/pod; **PPD**-Number of pods/peduncle; **LP**-Length of peduncle; **DFF**-Days to flowering.

Table 4: Allelopathic effect of rice husk (20g) on some yield components of cowpea.

Treatment 2 (Rice Husk at 20g)							
Varieties	**NPP**	**LP**	**NSP**	**SP**	**PPD**	**LPP**	**DFF**
NGB07/11	11.00[a]	17.33[a]	78.66[a]	7.33[a]	5.00[a]	17.66[a]	69.00[a]
NGB01643	14.00[a]	16.78[a]	84.33[a]	6.00[a]	6.33[a]	16.50[a]	71.00[a]
NGB01642	6.66[b]	12.66[b]	44.00[b]	6.66[a]	3.00[b]	16.33[a]	71.00[a]
NGB0055	19.00[a]	15.91[a]	121.23[a]	6.66[a]	9.00[a]	16.66[a]	70.00[a]
LSD	**10.92**	**3.88**	**50.23**	**1.79**	**5.68**	**12.14**	**2.82**

Means with the same letter in the column do not differ significantly (P<0.05).

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Keys

NPP-Number of pods/plant; **PL**-Pod length; **NSP**-Number of seeds/plant; **SP**-Number of seeds/pod; **PPD**-Number of pods/peduncle; **LP**-Length of peduncle; **DFF**-Days to flowering.

Table 5: Allelopathic effect of rice husk (40g) on some yield components of cowpea.

Treatment 3(Rice husk at40g)							
Varieties	**NPP**	**PL**	**NSP**	**SP**	**PPD**	**LP**	**DFF**
NGB07/11	8.33[c]	11.83[a]	48.00[b]	4.00[a]	3.66[b]	15.76[a]	44.66[a]
NGB01643	18.33[a]	17.31[a]	115.00[a]	6.66[a]	9.00[a]	15.00[a]	68.33[a]
NGB01642	14.00[b]	16.12[a]	92.33[b]	6.66[a]	6.66[a]	17.16[a]	69.33[a]
NGB0055	21.66[a]	14.49[a]	147.66[a]	7.00[a]	9.66[a]	17.83[a]	70.33[a]
LSD	**6.98**	**10.52**	**48.84**	**4.09[a]**	**3.21**	**11.43**	**38.46**

Means with the same letter in the column do not differ significantly (P<0.05).

⇧

Keys

NPP-Number of pods/plant; **PL**-Pod length; **NSP**-Number of seeds/plant; **SP**-Number of seeds/pod; **PPD**-Number of pods/peduncle; **LP**-Length of peduncle; **DFF**-Days to flowering.

Table 6: Proximate analysis of cowpea.

Moisture	Total ash	Crude fibre	Crude fat	Crude protein	Carbohydrate	Energy (Kcal/100g)
13.86±0.20	**3.48±0.30**	**4.85±0.02**	**1.15±0.02**	**22.62±0.01**	**54.04±0.15**	**316.99±0.02**

Discussion

Plant height was significantly influenced by the allelopathic treatment during the germination, vegetative and reproductive stages. Findings from this study indicated that rice husk promote the growth of cowpea as NGB01643 had better performance than other varieties considered at every stage of development. This is not in agreement with [19], who reported that root length of *Trianthema portulacastrum* was affected by sorghum water extract and significantly reduced by high concentration of 75 and 100% sorghum water extract. Findings from this study revealed that rice husk extract inhibit the stem girth of cowpea at higher concentrations. These may suggest an increase in the concentration of allelochemicals

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like phenolics. The concentration of rice husk extract and its attendant implications on the stem girth of the cowpea varieties in agreement with findings of [20] while working on tomato (*Solanum lycopersicon* L.) revealed that rice husk residue (RHR) increased the stem girth of NGB01301 and NGB01232. [21] earlier reported that the water and methanolic extracts of *Withania somnifera* drastically suppress the germination, root and shoot growth of *Parthenium hysterophorus*. The observed variations in the allelopathic effect of rice husk on the morphological parameters of cowpea investigated suggest that the inhibitory or stimulatory roles of allelochemicals released by rice husk are not only concentration specific but also depend on the stage of development of the varieties under study. Findings from this study are also corroborated by several workers on the allelopathic potential of common weeds on germination, seedling growth and yield of several crop species [22-24]. The observed inhibitory role of rice husk at 20g and 40g concentrations respectively on the leaf area and number of branches of cowpea is not in agreement with [25], who reported that root exudates of *Tithonia diversifolia* significantly inhibited the germination, growth and chlorophyll accumulation of tomato. Similarly, allelopathic water extract application at lower concentration has been observed to stimulate germination and growth of different crop [26-28]. Plant growth regulators are imperative in enhancing source-sink relationship and promote the translocation of photosynthates thereby aiding effective flowering, fruit and seed development [29]. The observed stimulatory role of rice husk at different concentrations in the number of pods/plant, number of seeds/plant, number of seeds/pod in the cowpea varieties could be attributed to a rich deposit of active components inherent in rice husk in promoting the yield components of cowpea. [30], while working on wheat, reported that salicyclic acid increases the number of flowers, pods/plant and seed yield of soybean.

Conclusion

Plant height of NGB01643 was significantly affected by rice husk at 20g concentration. The growth parameters of cowpea at various concentrations were not only concentration specific but stage dependent as exemplified in the effect of rice husk on the growth and yield of cowpea. The observed variations in the potential effect of allelopathy on the morphological parameters at every stage of cowpea investigated led credence to the inhibitory or stimulatory role of allelochemicals released by the rice husk. Hence, the inclusion of allelopathic substances into agricultural management may be a panacea to reduce environmental degradation posing a serious threat to biodiversity.

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