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Response of cowpea [*Vigna unguiculata* (L.) Walp] to residual effect of different application rates of sheep manure on chilli pepper (*Capsicum annuum*)

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Abstract

Field experiments were conducted in 2005 and 2006 rainy season at the Institute for Agricultural Research farm, Samaru, Nigeria, to test the response of four cowpea [*Vigna unguiculata* (L) Walp] varieties to residual effect of four rates of sheep manure (FYM) (0, 5, 10 and 15 t/ha) applied the previous season to chilli pepper [*Capsicum annuum*]. Each of the experiment was a follow up to a previous one conducted in 2004 and 2005 to test the response of pepper to those rates of FYM. Applications of different rate of FYM had significant residual effect on soil chemical content. The combined results showed significant difference among the cowpea varieties for grain yield and yield components. Mean cowpea grain yield ranged from 1.7 t/ha in IT96D-757 to 2.7 t/ha in IT97K-499-35. Previous FYM application rate significantly affected cowpea grain yield, pod weight, number of seeds per pod, seed weight per pod and threshing percentage. However, 100-seed weight was not significantly affected. Cowpea grain yield ranged from 1.4 t/ha in plots without FYM to 2.4 t/ha in plots that had 10 or 15 t/ha previous year. Significant interaction was not observed between cowpea variety and previous manure application rate.

Key words: Cowpea, farmyard manure, residual effect of manure, yield attributes.

Introduction

Nigeria is the world's largest producer of cowpea [*Vigna unguiculata* (L.) Walp] with grain production estimated at 2.8 million Mt on 4.1 million ha [1]. The crop is an important grain legume in the savannas of West Africa providing a cheap source of vegetable protein to the urban and rural poor, as well as mineral and protein rich fodder for livestock feeding and cash to the farmers [2, 3].

Cowpea production like most other crops is constrained by a number of biotic and abiotic factors such as poor nutrient status in soils, drought, traditional planting systems, pests and diseases among others [4-6]. The bulk of the cowpea in Nigeria is produced in the dry savannas and is grown either as intercrop in the Sudan savanna or relayed with other cereal crops like maize, sorghum and millet in the Guinea savanna zone. Farmers generally do not use inputs like fertilizer and insecticide, as it is widely believed that the production of cowpea and other legumes do not require external inputs, especially organic and inorganic fertilizers [7]. This was due to excessive vegetation produced by cowpea when grown on fertile soils or when nitrogenous fertilizers are used; the excessive vegetation may sometimes lower grain yields. However, results from research stations [6-8] have reported enhanced productivity of cowpea crop when supplied with fertilizer, particularly on poor soils. With increase in human population and attendant intensification, organic as well as inorganic fertilizers are required to maintain or improve production of most crops. Fertilizers of organic source are known for enhancing the macro and micronutrient contents of the soil, soil water holding capacity, pH and soil structure [9-11]. It has been noted [8] that application of organic manure has a more lasting beneficial residual effect that can remain significant up to four seasons when compared with inorganic fertilizers whose residual benefit do not last beyond one season. Enhanced crop performance has been reported in situation of high residuals from successive farming operations [8]. The response usually varied among crop species. Development of high yielding cowpea genotypes by research institutes is encouraging farmers to shift toward monoculture system, since they grow the crop mostly as cash crop [12]. Rotation of cereals with legumes has been extensively studied in recent years. Use of rotational systems involving legumes is gaining importance throughout the West Africa savanna regions because of economic and sustainability considerations. The amount of nitrogen fixed by leguminous crops can be quite high, although it has been demonstrated that legumes can also deplete soil nitrogen[13]. Apart from nitrogen fixation, there are many other positive effects of grain legumes rotation with cereals: such as the improvement of soil biological and physical properties and the ability of some legumes to solubilize occluded phosphorus and highly insoluble calcium-bound phosphorus by root exudates [14]. Other advantages of crop rotation include soil conservation, organic matter restoration, and pest and disease control [15]. Rotating cowpea or other legumes with high value crops that respond to organic and inorganic fertilizer will be an efficient way of utilizing the overall fertilizer inputs. Chilli pepper (*Capsicum annuum*) is one of such high value crop. In light of the above, the present study was undertaken with the aim of determining most productive cowpea variety for Samaru and also to determine the residual effect of different rate of sheep dung (FYM) applied on pepper on the productivity of subsequent cowpea crops.

Materials and Methods

The experiments were conducted at the Institute for Agricultural Research farm, Samaru (11°11'N, 07°38'E, 686 m above the sea level) during 2005 and 2006 rainy seasons. Different plots location within the research farm was used in the different years.

Each of the experiment followed a previous season (2004 and 2005) experiment conducted to study the response of chilli pepper to four rates (0, 5 10 and 15 t/ha) of FYM. The experiment was arranged in a split-plot design replicated three times. The treatments consisted of cowpea varieties (main plot) and FYM as subplot. The cowpea varieties used were extra early (IT93K-452-1), early maturing (IT90K-82-2 and IT97K-499-35) and medium maturing (IT96D-757). The land was sprayed with herbicide and ridged 7 days later. Ridging was done using tractor drawn ridges with a spacing of 75 cm between ridges. Cowpea was planted at 25 cm within ridge sowing 3 seeds per hole which was later thinned to two plants per stand at 2 weeks after sowing (WAS). The gross and net plot size were 9 m^2 and 3 m^2, respectively. The crops were sown on July 17th 2005 and 2006. Subsequent weed control was done by manual hoe weeding carried out at 3 WAS and earth up of ridges at 5 WAS.

In each year, soil samples were taken from the main plot treatment and analyzed for physicochemical properties. A bulk sample was also taken for the whole plot and analyzed for physical properties (Table 1). Daily rainfall data were collected from the meteorological department of the institute which had a weather station on the farm complex. Data were collected at harvest and included number and weight of seeds per pod, pod weight, threshing percentage (%), 100-grain weight and grain yield. All the crop data collected were statistically analyzed using Proc GLM and treatment means were separated using New Duncan's Multiple Range test [16].

Table 1. Chemical and physical properties of bulk soil sample in 2005 and 2006 plots.

Soil property	2005	2006
Sodium (meq/100 g)	1.70	4.37
Calcium (meq/100 g)	5.90	0.06
Magnesium (meq/100 g)	0.32	0.54
CEC (meq/100 g)	11.4	9.6
Clay (%)	24	18
Silt (%)	60	38
Sand (%)	16	44
Textural class	Silty loam	Loam

Results

In 2005, the rain started in April, rised continuously up to September and ended with light shower in October, while in 2006 rain started in May, reached its peak in August and ended in October with a total of 1090.4 mm in 2005 and 1112 mm in 2006 (Fig. 1). Thus, the rainfall patterns in the two years were similar and a rainfall difference is therefore not expected to affect the cowpea performances significantly.

The residual effect of different rates of application of FYM on soil chemical contents in proceeding year is given in Fig 2. The FYM application had significant residual effect on the chemical contents of the soils. The 2006 plots generally had higher content of P and K in the soils but lower content of organic carbon and N and lower pH. Soil pH, organic carbon and potassium and phosphorus contents of the soil increased with increasing rates of FYM. The residual K content was slightly affected by varying rates of previous season applied FYM. Residual nitrogen was highest in the plot that received FYM 10 t/ha beyond which the residual N declined.

The effect of cowpea varieties and residual FYM rate on weight of cowpea pods and number and weight of seeds per pod of four cowpea varieties are given in Table 2. Significant variation was observed among the cowpea varieties for pod weight, number of seeds per pod and seed weight per pod. IT97K-499-35 had significantly higher mean pod weight (3 g), number of seeds per pod (13) and seed weight per pod (2 g) than other cowpea varieties tested. Significant differences were also observed on the residual effect of previous season applied FYM on the weight of cowpea pods, number and weight of seeds per pod. Varying the previous year manure rate from 0 to 5 t/ha significantly increased mean weight of pods from 1.9 to 2.4 g, number of seeds per pod was increased from 10.7 to 12.2 while seed weight per pod increased from 1.5 to 1.9 g. When FYM was further increased from 5 to 10 t/ha, mean pod weight (2.5 g) was significantly affected and number of seeds per pod (13.5) and seed weight per pod (2.1 g) significantly increased. There were significant residual effect of an increase of applied FYM rate from 10 to 15 t/ha on subsequent cowpea crop on mean pod weight (2.5 vs. 2.9 g), while it had no significant effect on number of seeds per pod and seed weight per pod. There was no significant interaction between cowpea varieties and residual effect of rate of FYM for yield attributes measured.

The effect of residual FYM on threshing percentage, 100-grain weight and grain yield of selected varieties of cowpea is presented in Table 3. Significant differences were observed among the cowpea varieties for threshing percentage, 100-grain weight and grain yield. IT93K-452-1 (79%) had significantly higher mean threshing percentage than IT96D-757 (76%) which was also significantly higher than for IT90K-82-2 (72%) and IT97K-499-35 (72%). IT96D-757 had significantly higher mean of 100- grain weight (16.2 g) than IT93K-452-1 and IT97K-499-35 (15 g for both) which were significantly higher than for IT90K-82-2 (13.8 g). IT97K-499-35 consistently recorded significantly higher grain yield (2.7 t/ha). There was no significant difference in the grain yields of the other three varieties. Application of manure on pepper showed significant effects on threshing percentage and grain yields of subsequent cowpea crop, but the effect on cowpea grain weight was not significant. The residual effect of FYM on cowpea threshing percentage was significant when FYM was increased from 10 to 15 t/ha but not significant between 5 and 10 t/ha and between 0 and 5 t/ha. However, the residual effect of FYM on cowpea grain yield was significant between the three application rates and the control but there were no significant differences among the different application rates of FYM. The interaction of variety and residual FYM on threshing percentage, 100-seed weight and grain yield were not significant.

Table 4 shows the correlation among yield and yield attributes of four varieties during the 2005 and 2006 rainy seasons. The results revealed a positive and significant correlation between grain yield and all the other yield components measured except 100-grain weight; the relationship between grain yield and 100-

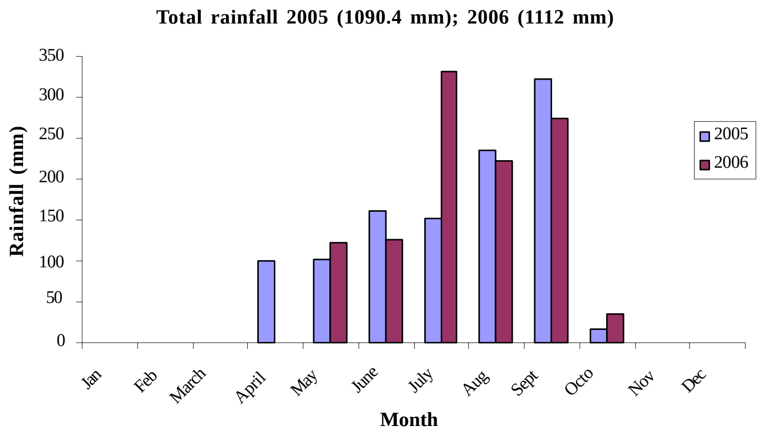

Figure 1. Monthly rainfall (mm) at Samaru in 2005 and 2006.

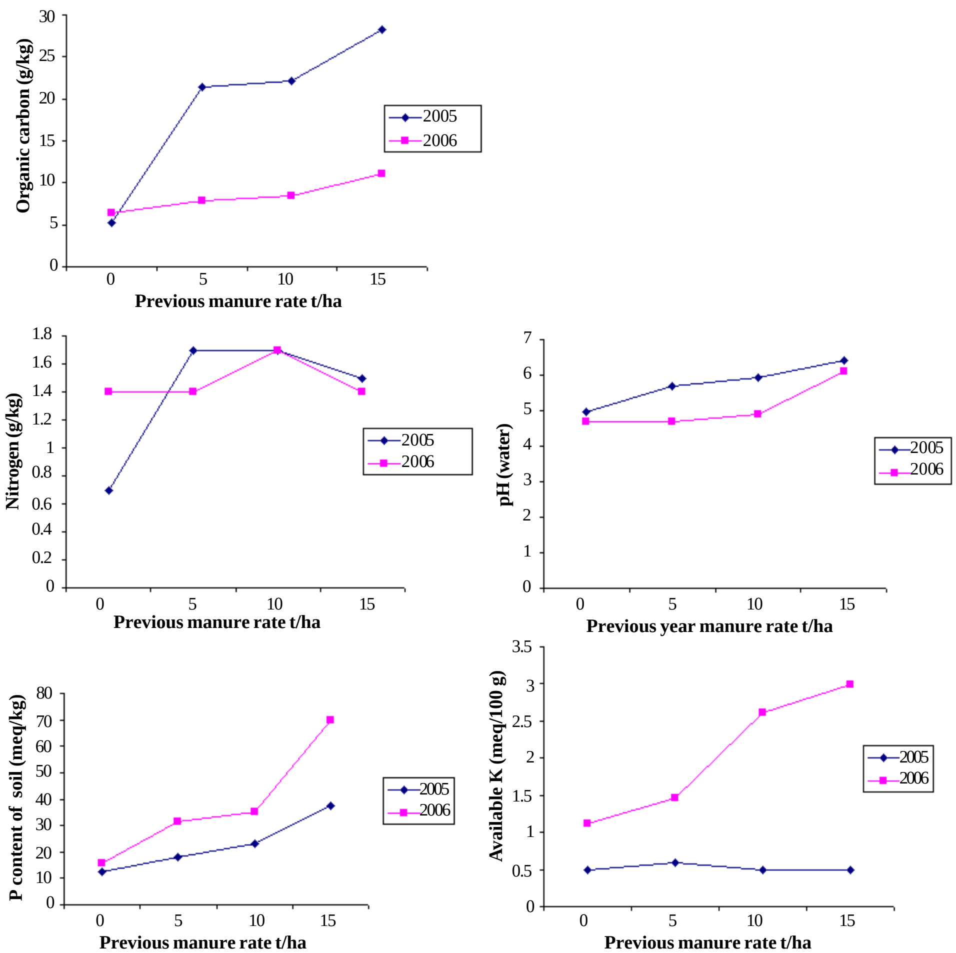

Figure 2. Residual effect of different rates of application of FYM on soil chemical contents.

grain though positive was not significant. Grain yield recorded stronger relationship with the yield parameters. The relationship between pod weight and number of seeds (r = 0.5253) as well as seed weight per pod in 2005 and that between number and weight of seeds in 2005 (r = 0.6171) and 2006 (r = 0.6694) was positive and highly significant. Threshing percentage was negatively correlated with all other parameters. The correlations that exist among other parameters though positive were not significant.

Discussion

The significant variation recorded among the varieties tested in terms of the yield and yield parameters could be genetic as earlier observed [17]. Many cowpea varieties are being developed based on their suitability for environmental conditions. Among the varieties tested in this trial IT97-499-35 was superior to others in most of the parameters measured except threshing percentage and 100-seed weight. This shows that higher harvestable seeds

Table 2. Residual effect of different rates of sheep manure on number and weight (g) of seeds per pod and weight per pod of selected cowpea varieties at Samaru.

Treatment	Pod weight (g)			Number of seeds per pod			Seed weight/pod (g)		
	2005	2006	Mean	2005	2006	Mean	2005	2006	Mean
Variety									
IT93K-452-1	1.9b	2.2c	2.1b	10.6b	13.5	12.1b	1.5b	2.1ab	1.8b
IT90K-82-2	1.9b	2.6b	2.3b	12.0a	13.4	12.7a	1.6ab	1.9c	1.8b
IT97K-499-35	2.2a	3.7a	3.0a	11.8a	14.1	13.0a	1.7a	2.2a	2.0a
IT96D-757	2.0b	2.6b	2.3b	11.0b	12.3	11.7b	1.5b	2.0bc	1.8b
SE±	0.07	0.24	0.10	0.26	0.43	0.20	0.06	0.07	0.05
Residual manure (t/ha)									
0	1.7b	2.0c	1.9c	10.0c	11.4c	10.7c	1.3b	1.6c	1.5c
5	2.1a	2.6bc	2.4b	11.2b	13.1b	12.2b	1.7a	2.0b	1.9b
10	2.2a	2.8b	2.5b	12.4a	14.6a	13.5a	1.7a	2.4a	2.1a
15	2.1a	3.6a	2.9a	11.8bc	14.2ab	13.0a	1.6ab	2.3a	2.0ab
SE±	0.07	0.24	0.10	0.26	0.43	0.20	0.06	0.07	0.05
Interaction									
V x M	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by unlike letter(s) within a column are significantly different at 5% level using DMRT, NS Not significant.

Table 3. Residual effect of different rates of sheep manure on threshing percentage, 100-seed weight and grain yield (t/ha) of selected cowpea varieties at Samaru.

Treatment	Threshing percentage (%)			100-seed weight (g)			Grain yield (t/ha)		
	2005	2006	Mean	2005	2006	Mean	2005	2006	Mean
Variety									
IT93K-452-1	73a	85a	79a	16.0b	13.9b	15.0b	1.7b	2.2b	2.0b
IT90K-82-2	69b	74c	72c	15.5b	12.0c	13.8c	1.7b	2.1b	1.9b
IT97K-499-35	67c	77bc	72c	16.0b	13.9b	15.0b	2.2a	3.1a	2.7a
IT96D-757	71ab	81ab	76b	17.5a	14.8a	16.2a	1.3c	2.0b	1.7b
SE±	1.07	2.0	0.84	0.22	0.16	0.14	0.07	0.26	0.18
Residual manure (t/ha)									
0	71	79b	75ab	16.4	13.8	15.1	1.4b	1.3b	1.4b
5	71	76b	74b	16.0	13.4	14.7	1.8a	2.4a	2.1a
10	70	77b	74b	16.0	13.4	14.7	1.9a	2.9a	2.4a
15	68	85a	77a	16.5	13.7	15.1	1.9a	2.8a	2.4a
SE±	1.07	2.0	0.84	0.22	0.16	0.14	0.07	0.26	0.18
Interaction									
V x M	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by unlike letter(s) within a column are significantly different at 5% level using DMRT, NS Not significant.

Table 4. Correlation matrix of yield and yield attributes of four varieties of cowpea at Samaru during 2005 rainy season.

		1	2	3	4	5	6
1	Grain yield	1.00					
2	Weight/pod	0.4797**	1.00				
3	Number of seeds/pod	0.5260**	0.5253**	1.00			
4	Seed weight/pod	0.5112**	0.8075**	0.6171**	1.00		
5	Percent threshing	-0.1017	-0.3363	-0.2555	-0.1292	1.00	
6	100-seed weight	0.3067	0.021	-0.2065	0.0897	-0.0458	1.00

** significant at 5%.

are able to outweigh the advantages of heavier seeds. The grain yield produced by IT97-499-35 was 26% more than that produced by IT93K-452-1, 30% more than IT90K-82-2 and 37% more than that of IT96D-757 when the two years data were combined. Similar yield differences in cowpea had earlier been reported [12, 3]. IT97K-499-35 has combined resistance to *Striga*, *Alectra* and several other biotic and abiotic stresses common in this location [18] and this may have influenced the performance of this variety.

The significant response of cowpea to previous season applied FYM could be due to the supply of essential nutrients required by crop by the organic manure [10]. The manure is believed to increase yields of cowpea as a result of improved water holding capacity, soil aeration, soil structure, nutrient retention and microbial activities, all of which are known to play a significant role in enhancing crop performance [9, 19]. Soil testing indicated that the unfertilized plots contained lower nutrient contents than the manured plots. Sheep manure is believed to have higher concentration of nutrients than manures from larger animals like cattle thereby enhancing the fertility of the soil [19]. When manure was applied in the soil, it tends to have a longer lasting effect as indicated by the positive response of the cowpea to previous season applied FYM. Similar studies were reported as well [8].

The yield and yield attribute response by cowpea to residual effect of application of FYM was observed to be mostly only up to 10 t/ha for most of the yield attributes and 5 t/ha for grain yield suggesting the requirements for these parameters are met at these rates. Yield produced by cowpea following chilli pepper supplied with FYM 5 t/ha was 29 and 85% more than that produced by the control in 2005 and 2006, respectively. It had been reported [8] that the effect of manure applied to the soil can remain significantly up to four seasons while that of mineral NPK fertilizer remained for only one season. The positive relationships that were recorded between grain yield and number and weight of seeds per pod as well as pod weight indicates the importance of these parameters as major yield contributors in cowpea.

Conclusions

Significant variations were observed among cowpea varieties tested. Cowpea variety IT97K-499-35 produced higher grain yield than the other varieties tested in this trial and should be promoted among farmers in the Sudan savanna zone of Nigeria. Application of FYM had a significant residual effect on productivity of succeeding cowpea. Rotation of cowpea with high value crops such as chilli pepper and other vegetables is recommended. Residual effect of FYM manure applied to chilli pepper in the previous season can sustain the growth and productivity of succeeding cowpea crop without the need for further application in the cropping season. This will improve the sustainability of the cropping system and help maintain soil fertility.

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