Original Article

Agricultural Science

Response of Grain Amaranth (*Amaranthus cruentus* L) to Nitrogen and Farmyard Manure Rates in Northern Guinea and Sudan Savanna Ecological Zones of Nigeria

Joseph Nda AINIKA, Bindawa Mansur AUWALU, Abdulhameed Umar YUSUF

ABSTRACT [ENGLISH/ANGLAIS]

A field experiment was conducted during the 2009 wet season at two locations. Institute for Agricultural Research Farm, Samaru (11^{0}11'N, 07^0 38'E, 686 m above sea level) in the Northern Guinea Savannah ecological zone; and Irrigation Research Station of the Institute for Agricultural Research Kadawa (11^{0}39'N, 08^0 027'E, 500m above sea level), in the Sudan Savannah ecological zone of Nigeria, to study the response of grain amaranth (*Amaranthus cruentus* L.) to nitrogen fertilizer and farmyard manure. The treatments consisted of four rates of nitrogen (0, 50, 100 and 150 kg N ha^{-1}) and three rates of farmyard manure (0, 4 and 8 t ha^{-1}) arranged in a randomized complete block design and replicated three times. Nitrogen at the rate of 50 kg N ha^{-1} and farmyard manure at the rate of 4 t ha^{-1} respectively significantly increased plant height, plant dry weight, leaf area index, and crop growth rate but the total grain yield of the crop was not affected by the treatments in both locations. Application of nitrogen fertilizer in the absence of farmyard manure or vice versa which was statistically similar to application of 50 kg nitrogen fertilizer + 4 t ha^{-1} farmyard manure, and each produced significant growth responses. Therefore, application of farmyard manure at the rate of 4 t ha^{-1} in the absence of nitrogen fertilizer gave the optimum grain yield of amaranth.

Keywords: Grain amaranth, nitrogen, farmyard manure, yield, savanna

RÉSUMÉ [FRANÇAIS/FRENCH]

Une expérience de terrain a été menée pendant la saison 2009 à deux endroitshumides. Institut de recherche agricole Farm, Samaru (11^{0}11'N, 07^0 38'E, 686 m d'altitude) dans le Nord de la Guinée Savannah zone écologique, et la station de recherche d'irrigation de l'Institut de recherche agricole Kadawa (11^{0}39'N, 08^0 027'E, 500m d'altitude), dans la zone de savane soudanienne écologiques du Nigeria, pour étudier la réponse des grains d'amarante (Amaranthus cruentus L.) pour les engrais azotés et de fumier de ferme. Les traitements consistaient enquatre taux d'azote (0, 50, 100 et 150 kg N ha^{-1}) et trois taux d'engrais de ferme (0, 4 et 8 t ha^{-1}) disposées en blocs aléatoires complets et répétés trois fois . L'azoteau taux de 50 kg N ha^{-1} et du fumier à raison de 4 t ha^{-1} respectivement la hauteur des plantes considérablement augmenté, le poids sec de la plante, l'indice foliaireet le taux de croissance des cultures, mais le rendement en grains de la récoltetotale a été pas affectée par les traitements dans les deux endroits. Application desengrais azotés, en l'absence de fumier ou vice versa qui était statistiquementsimilaire à l'application de 50 kg d'engrais azoté + 4 t ha^{-1} du fumier de ferme, et chacun produit une croissance importante des réponses. Par conséquent, l'application de fumier au taux de 4 t ha^{-1} en l'absence d'engrais azotés a donné lerendement en grains d'amarante optimale.

Mots-clés: Grains d'amarante, de l'azote, de fumier, le rendement, la savane

Affiliations:

Faculty of Agriculture, Bayero University Kano, NIGERIA

Address for Correspondence/ Adresse pour la Correspondance: roboainika@ymail.com

Accepted/Accepté: October, 2011

Citation: Ainika JN, Auwalu BM, Yusuf AU. Response of Grain Amaranth (Amaranthus cruentus L) to Nitrogen and Farmyard Manure Rates in Northern Guinea and Sudan Savanna Ecological Zones of Nigeria. World Journal of Engineering and Pure and Applied Sciences 2011;1(2):46-9.

INTRODUCTION

Grain amaranth growers apply minimal or zero fertilizer to their crops while some farmers apply high rate to their crop like in other cereal crops. The problem in this respect is that farmers who apply higher rate of fertilizer end up with excessive vegetative growth at the detriment of grain formation while farmers who do not apply fertilizer at all may end up with low grain yield depending on the fertility of the soil.

Grain amaranth (*Amaranthus cruentus* L.) contains high protein (15 to 18%), lysine, and calcium concentrations but lacks gluten [1]. Hackman and Myers [2] Identified the favorable nutritional profile of the grain amaranth as one of the three key reasons that motivate consumers to purchase grain amaranth, others include: people affected by celiac disease need gluten-free food, and the desire for more exotic food. However, in most developing countries of the world including Nigeria no concerted effort has

been done with respect to research on cultural or agronomic practices such as optimum fertilizer needs of grain amaranth in order to boost its production in the country. In this view, this study was designed to determine the effect of nitrogen and farmyard manure (FYM) on the growth and yield of grain amaranth.

MATERIALS AND METHODS

A field experiment was conducted during the 2009 wet season at two different locations –the Research Farm of the Institute for Agricultural Research (IAR), Ahmadu Bello University (ABU) Samaru Zaria ($11^0 11'$N, 07^0 38'E, , 686 m above sea level) in the northern Guinea Savanna ecological zone of Nigeria; and the Irrigation Research Station, Kadawa of IAR/ABU (11^0 39', 080 027' E and 500 m above sea level), in the Sudan Savanna ecological zone of Nigeria. A composite soil sample for each of the experimental sites from 0-30 cm depth was taken with the use of an auger at random locations for physical and chemical analysis using standard procedures. Farmyard manure (cattle manure of one year old) that was sourced from Samaru college of Agric livestock unit was analyzed to determine the nutrient contents. Rainfall data and other meteorological information at the two sites were recorded.

The experiment was made up of twelve treatments consisting of four levels of nitrogen (0, 50, 100 and 150 kg N ha^{-1}) and three levels of farmyard manure (0, 4 and 8 t ha^{-1}). The treatments were factorially combined, laid out in a randomized complete block design, and replicated three times. Seeds of grain amaranth (*Amaranthus cruentus* L.) Cultivar obtained from National Institute for Horticultural Research and Training (NIHORT) Ibadan was sown in the nursery within an orchard of Agronomy department by drilling. The nursery bed were mulched after sowing and irrigated regularly. The mulch was removed immediately after germination and rearranged between drill-rows of the emerged seedlings.

The experimental site was ploughed harrowed and prepared into ridges 75 cm apart and marked into plots and replicates. Adjacent replicates were separated by 1.0m-wide alley ways, and adjacent plots by a ridge. The field was marked into five rows with two middle rows as the net plot and the third middle row for sampling. The gross plot size was 3.75 × 3 m (11.25 m^2). Matured seedlings of three weeks old were transplanted to the open field at a stand spacing of 25 × 75 cm. Farmyard manure was incorporated according to treatment level to specific plots during land preparation. The inorganic fertilizer Urea (46% N) was applied as per the treatment levels by side-dressing in two equal doses. The first dose was applied at one week after transplanting and the remaining at two week after in amount according to treatment. The field was weeded manually using a small hand hoe. A total of two weeding were adequate for weed control carried out at two and four weeks after transplanting. Being a vegetative crop that is harvested for use at various stages of growth, a sample of the Amaranth was regularly harvested at two weeks interval. The final harvest was done at 110 days after transplanting, by cutting the heads when the grains attained physiological maturity. Then, it was dried, winnowed and bagged.

At two weeks interval, data were collected from three destructive sampled plant and later oven tried at 70 ^{0}C. This includes plant height, plant dry weight, leaf area index, crop growth rate and total grain yield. Data collected were subjected to analysis of variance (ANOVA) which involves the use of 'F' test [3]. Following significant ANOVA, the treatment means were compared using Duncan Multiple Range Test [4].

RESULTS AND DISCUSSION

Effect of Nitrogen Fertilizer

Results showed that application of nitrogen at the rate of 50 kg N ha^{-1} significantly increased the vegetative growth and development of grain amaranth through increased plant height, plant dry weight, leaf area index, and crop growth rate but the total grain yield of the crop was not affected in both locations. Plants treated with 50 kg N ha^{-1} of nitrogen were higher in such growth characters compare with the control. However, further increase of nitrogen fertilizer above 50 kg N ha^{-1} was statistically non-significant. The result corroborates with Manga [5] who reported that the application of nitrogen fertilizer at the rate of 50 kg N ha^{-1} was the optimum for growth and yield of grain amaranth in the savanna ecological zones of Nigeria.

Effect of Farmyard Manure

Results showed that application of farmyard manure at the rate of 4 t ha^{-1} significantly increased the vegetative growth and development of grain amaranth through increased plant dry weight, leaf area index, and crop growth rate in Samaru location. All other characters including total grain yield of the crop were not affected in both locations. The result from this work has shown the role played by farmyard manure in supplying nutrient, gradual release of nutrient and impacting its physical effects on soil condition through good aeration,

water holding capacity, structure, and increased microbial activities. This result is in line with the report of Cook [6] who found that farmyard manure supply both its physical effects on soil condition, the nutrient it supplies and the way it supplies the nutrient thereby sustaining cropping system.

Interaction of Nitrogen Fertilizer and Farmyard Manure

Application of nitrogen fertilizer at the rate of 150 kg N ha^{-1} in combination with farmyard manure at the rate of 8 t ha^{-1} significantly increased leaf area index of the crop than all other possible combination (Table 2), while combination of nitrogen at 100 kg N ha^{-1} and farmyard manure at 4 t ha^{-1} showed superiority over other possible combination for crop growth rate (Table 3). For total grain yield, application of farmyard manure at the rate of 4 t ha^{-1} in the absence N-fertilizer gave the optimum grain yield of the crop at Samaru only. This result is statistically similar to that from 50 kg N/ha + 4 t farmyard manure ha^{-1} (Table 4). The result has shown the complementary role played by combining organic and

Table 1: This table shows the effect of Nitrogen and Farmyard Manure on Grain Amaranth Growth and Yield Characters in 2009 Rainy Season at Samaru and Kadawa

Treatment	Plant height (cm) 7WAT		Plant dry weight (g) 5WAT		Leaf area index 5WAT		Crop growth rate (g/m^2/wk) 5WAT		Total grain yield (kg ha^{-1})	
	Samaru	Kadawa	Samaru	Kadawa	Samaru	Kadawa	Samaru	Kadawa	Samaru	Kadawa
Nitrogen (kg N ha^{-1})										
0	133.3	132.1b	28.7b	40.2	11.2	12.9	19.2a	35.4	1158	830
50	142.6	148.9a	34.5ab	43.6	12.2	15.4	26.6ab	39.0	1497	929
100	146.3	141.6a	42.8a	48.3	12.9	14.2	32.8a	43.6	1449	906
150	150.2	138.1ab	34.1ab	42.5	18.1	13.6	25.4ab	37.5	1173	860
SE±	8.45	1.69	3.94	5.51	2.96	1.92	3.31	5.29	138.5	78.4
FYM (t ha^{-1})										
0	132.3	136.1	29.2b	38.4	7.7b	13.0	20.0b	33.4	1303	769
4	154.0	144.9	43.2a	48.4	16.1a	15.5	34.6a	43.5	1340	964
8	143.0	139.5	32.7b	44.0	17.1a	13.7	23.6b	39.6	1314	912
SE±	7.32	4.56	3.41	4.77	2.44	1.67	2.87	4.58	119.9	67.9
N*F	NS	NS	NS	NS	*	NS	*	NS	*	NS

*Means within a treatment column followed by same letter(s) indicate that they are statistically similar (P > 0.05) using DMRT, * = Significant at 5%, NS = Not significant at 5%, WAT = Weeks after Transplanting*

Table 2: This table shows the interaction between Nitrogen Fertilizer and Farmyard Manure on Leaf Area Index (LAI) of Grain Amaranth at Five Weeks after Transplanting in 2009 Rainy Season at Samaru.

Nitrogen (kg ha^{-1})	Farmyard Manure (t ha^{-1}) 0	4	8
0	2.1 ^{cd}	2.1 ^{cd}	2.7 ^{cd}
50	4.2 ^{bc}	3.6 ^{bcd}	2.9 ^{cd}
100	1.7 ^{d}	3.0 ^{cd}	5.3 ^{b}
150	2.0 ^{d}	3.2 ^{cd}	7.3 ^{a}
SE ±		0.64	

Means followed by the same letter(s) indicate that they are statistically similar (p > 0.05).

Table 3: This table shows the interaction of Nitrogen and Farmyard Manure on Grain Amaranth Crop Growth Rate (g/m^2/week) at Three Weeks after Transplanting in 2009 Rainy Season at Samaru

Nitrogen (kg ha^{-1})	Farmyard Manure (t ha^{-1}) 0	4	8
0	16.5 ^{de}	26.5 ^{bcd}	15.1 ^{e}
50	27.6 ^{bc}	27.9 ^{bc}	24.4 ^{bcde}
100	19.1 ^{cde}	55.4 ^{a}	24.0 ^{bcde}
150	16.7 ^{de}	28.5 ^{bc}	30.9 ^{b}
SE ±		3.312	

Means followed by the same letter indicate that they are statistically similar (p > 0.05).

inorganic fertilizer in the release of nutrient steadily over time, improved soil fertility status by activating the soil microbial activities as reported by [7] and also [8] who reported that a combination of maize Stover compost and Urea fertilizer at rate of 3.0 t ha^{-1} + 30 kg N ha^{-1} significantly enhanced amaranth growth and yield attributes. Similarly, this findings tally with that of [9] who reported that high and sustained crop yield can be obtained with judicious and balanced nitrogen combined with organic matter amendment.

In conclusion, application of nitrogen fertilizer (urea 46%) at the rate of 50 kg N ha^{-1} in combination with 4 t ha^{-1} of farmyard manure is enough for enhanced growth and development of the crop. However, to maximize grain yield of amaranth on upland soil of the Sudan and northern guinea savanna ecological zones of Nigeria 4 t/ha of farmyard manure is adequate.

Table 4: This table shows Nitrogen and FYM Interaction on Grain Amaranth Total Grain Yield (kg ha^{-1}) at Samaru in 2009 Rainy Season

Nitrogen (kg ha^{-1})	Farmyard Manure (t ha^{-1})		
	0	4	8
0	668.7 ^{c}	1399.1 ^{ab}	1380.4 ^{ab}
50	693.0 ^{c}	1295.9 ^{abc}	1211.3 ^{bc}
100	1259.3 ^{bc}	1138.3 ^{bc}	1950.5 ^{a}
150	1427.3 ^{ab}	1422.7 ^{ab}	1982.4 ^{a}
SE ±		207.71	

Means followed by the same letter(s) indicate that they are statistically similar ($p > 0.05$)

REFERENCES

[1] Petr JI, Michalik H, Tlaskalova I, Capouchova O, Famera D, Urminska L. Tukova H, Knoblochova. Extension of the spectra of plant products for the diet in celiac disease. Czech Journal of Food Science 2003;21:59-70.

[2] Hackman D, Myers R. Market opportunities for grain amaranth and buckwheat growers in Missouri. Report to the Federal-State Marketing Improvement Program, 2003

[3] Snedecor GW, Cochran WG. Statistical Methods. IOWA State Universality Press IOWA USA. 1967. p. 456.

[4] Duncan DB. Multiple Ranges and Multiple F-Tests Biometric 1955;11:1-42

[5] Manga AA. Agronomic practices of grain amaranth (A. cruentus L) production in the northern guinea and Sudan savanna ecological zones of Nigeria. PhD Thesis 2001.

[6] Cook GW. Fertilizing for Maximum Yield. Granada a Technical Books 3rd Ed. Granada Publishing Limited, London. 1982. p. 465.

[7] Ayuso MA, Pascal JA, Garcia C, Hernades T. Evaluation of urban wastes for agricultural use. Soil Sciences and Plant Nutrition 1996;142:105-11.

[8] Akanbi WB, Togun AO. The influence of maize Stover compost and nitrogen fertilizer on growth, yield and nutrient uptake of amaranth. Sciatica Horticulturae 2002;93:1-8.

[9] Makinde EA. Effects of an organo-mineral fertilizer application on the growth and yield of maize. Journal of Applied Science Research 2007;3(10):1152-5.

ACKNOWLEDGEMENT / SOURCE OF SUPPORT

Authors wish to appreciate the supports from Post Graduate Research Committee, Agronomy Department, Faculty of Agriculture, Bayero University Kano, Nigeria.

CONFLICT OF INTEREST

No conflict of interests was declared by authors.