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EFFECT OF N, P AND FYM RATES ON DM ACCUMULATION AND UPTAKE OF K, CA AND MG BY ROSELLE (*HIBISCUS SABDARIFFA L.*) IN THE NORTHERN GUINEA SAVANNAH ZONE OF NIGERIA

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ABSTRACT

An investigation was conducted during 2005, 2006 and 2007 wet seasons at the experimental farm of the institute of Agricultural Research, Samaru (11° 11′N, 07° 38′E, 686m above sea level) to study the effect of N, P and farmyard manure (FYM) rates on dry matter (DM) accumulation and uptake of cations by Roselle in the Northern Guinea Savanna agro-ecological zone of Nigeria. The experiment consisted of three levels of N (0, 60 and 120 kg N ha^{-1}) in the form of urea, three levels of P (0, 13.2 and 26.4 kg P ha^{-1}) in the form of single super phosphate (SSP) and three levels of FYM (0, 5 and 10 t ha^{-1}). A total of twenty seven treatments were laid out in a split plot design with three replications. The factorial combinations of N and P were assigned to the main plots, while the FYM was allocated to the sub-plots. The result showed that application of 60 kg N and 5 t FYM ha^{-1} recorded significant increase in DM accumulation in Roselle, while applied P had no significant effect on DM production. Combined application of 120 kg N ha^{-1} with 5 t FYM ha^{-1} was optimum for DM production in Roselle. N application reduced K and Mg content but increased the uptake of the nutrients. Similarly, FYM reduced K and Ca content of shoots, while the uptake of these nutrients was increased by manure application. P application increased K and Mg, but reduced Ca contents of shoots. Application of P did not however exert significant effect ($P<0.05$) on the K and Mg uptake, but reduced Ca uptake of Roselle. Further trial of N application at higher rates is recommended in the study area.

KEY WORDS: DM Accumulation, FYM, Nutrients, Multiproduct, Roselle, and "Zoborodo"

INTRODUCTION

Roselle *(Hibiscus sabdariffa* L.) originated in the Tropical central area of West Africa (Murdock, 1995), and is a multi-product and multi-purpose annual plant belonging to the family *Malvaceae* cultivated in the tropical and sub-tropical regions for its leaves, edible calyces, seeds and fibre. In Nigeria and elsewhere, the leaves are used as a vegetable, while the calyces are major raw materials in local and commercial beverages for production of vitamin C enriched soft drinks popularly known as "*zoborodo"* or "*zobo"* and "Roselle apple" (Fasoyiro *et al.,*2005). Extracts from the calyces are widely used in the treatment of many diseases like: treatment of high blood pressure (Faraji and Tarkhani, 1999), treatment of pyrexia and liver disorders (Obiafuna *et al.,* 1994), cardiac, cancer and nerve diseases (Anon, 2008), and in the build-up of body immune system against diseases (CTA, 2001). It is an important source of natural coloring and flavoring agent in food and fruit processing industries (Mc Clintock, 2004). The seeds which contain 17-20% oil are a valuable source of edible oil (Rice *et al.,* 1993; Abu Tarboush *et al.,* 1997), and also a good source of protein (23%) with high tryptophan level (Rao, 1996). The seeds are fermented and boiled for local condiment (Mera *et al.,* 2007). It is also roasted and used as a local substitute for coffee (Morton, 1987; Aliyu and Morufu, 2006). Roselle is also an important source of fibre in India, Java and Philippines. The fibre content of fresh stem is 5-6% and 18-22% of dry weight (Rehm and Espig, 1991).

Currently, apart from the diverse uses of Roselle, the increased use of the calyces and the leaves in local and commercial beverages has led to an upsurge in demand for the crop in Nigeria. However, since production is still predominantly subsistent and mostly in mixture with other crops, and in which its specific nutrient needs and spacing are not considered, yields are generally low. As a result, the increased demand cannot be met unless appropriate production practices, especially the use of optimum rates of nutrients are adopted. Effective and efficient fertilizer use, however, emanates from the understanding of the crop's nutritional needs and its responses to nutrient supply. The relationship of nutrient supply and chemical contents of the plants were uncovered by the studies of Ulrich (1952) and Smith (1962). These relationships provide a firm basis for effective fertilizer recommendation for optimum yields of Roselle crops.

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Although there is a paucity of information on the nutritional needs of Roselle in Nigeria (Kumar *et al.,* 1985 and Aliyu, 1998), studies by Adamson *et al.,* (1979) and Bhangoo *et al.,* (1986) on Kenaf indicated that N application reduced K contents of whole plants, while the application of N and P increased K content and Ca uptake of pepper (Aliyu, 1994). This study was, therefore, undertaken to investigate the effect of N, P and FYM on DM accumulation and the uptake of K, Ca and Mg by Roselle plant.

Materials and Methods

The study was conducted during 2005, 2006 and 2007 wet seasons at the experimental farm of the Institute of Agricultural Research, Samaru (11^o 11′N, 07^o 38′E 686m above sea level) in the Northern Guinea Savanna ecological zone of Nigeria. This was to determine the effect of various combinations of 3 levels of N (0, 60 and 120KgNha^{-1}), 3 levels of P (0, 13.2 and 26.4kgPha^{-1}) and 3 levels of FYM (0, 5 and 10 t ha^{-1}) on the growth and nutrient uptake of Roselle (*Hibiscus sabdariffa* L.). Urea (46%N) and single super phosphate (18%P_2O_5) were used as sources of N and P, respectively, while the FYM (FYM) used was cowdung mixed with bedding materials. Before application, samples from the FYM were taken and analyzed in order to determine its chemical contents. A split plot design was used with factorial combination of N and P rates allocated to the main plots. Treatments were replicated three times. The gross plots (13.5m^2) were made up of 6 ridges of 3m (3x3m). Composite samples of soils at depths of 0-15 and 15-30cm were taken from the experimental sites prior to crop establishment and application of fertilizer treatments and analyzed for the chemical and physical properties using standard laboratory procedures (Black, 1965).

Planting was done on ridges at 75 cm apart and 3 m long at intra-row spacing of 60 cm. The application rates of P and FYM as well as the base dose of 30 kg K ha^{-1} were side banded and incorporated 2 weeks before Roselle seeds were planted. Two-hoe-weeding at 3 and 7 WAS and ridge molding at 11 WAS were done to control weeds. Karate (*Lambdacyhalothrin*) at the rate of 0.8 litre ha^{-1} along with Benlate (*benomyl*) at the rate of 1Kgai ha^{-1} were applied three times fortnightly using knapsack sprayer starting from 3 WAS each season as a routine preventive measure against pest and disease incidences. At 10 WAS, 2 plants were sampled randomly from each plot and thoroughly cleaned and dried to constant weight for the determination of total dry matter (TDM) after which it was ground with a Wiley mill and passed through a 2mm sieve. Total N in plant tissues was determined by Micro-Kjeldahl procedure (IITA, 1975). The percent concentration of P was determined by the vanodomolybdate yellow colour of Bray and Kurtz (1945) modified by Riley (1962). The concentration of K, Ca, and Mg were determined by atomic absorption spectrophotometry using Perking Elmer model 290B. The data collected were subjected to statistical analysis of variance as described by Senedecor and Cochran (1967). The data generated was analysed following the generalized linear model for the ANOVA (Statistix 8.0), while the differences between treatment means were determined using DMRT (Duncan, 1955).

RESULTS AND DISCUSSIONS

The soils of the experimental sites were: clay loam in 2005, loam in 2006 and sandy loam in 2007; with moderate acidity in 2005 and 2007, while it was strongly acidic in 2006 (Table 1). During the 3 seasons, the soils had low organic carbon, N and medium exchangeable K, while available P was low in 2005 but medium in 2006 and 2007 seasons. Detail of the physico-chemical properties of the soils of the experimental site is presented in Table I.

Table 1: Physico-chemical properties of soils of the experimental site during 2005, 2006 and 2007 wet seasons

	2005		2006		2007	
	Soil depth (cm)		Soil depth (cm)		Soil depth (cm)	
	0-15	15-30	0-15	15-30	0-15	15-30
Particle size distribution (%)						
Clay	18	42	24	24	10	26
Silt	52	22	34	34	32	34
Sand	30	36	42	46	58	40
Textural class	Silt loam	Clay	loam	Loam	Sandy loam	Clay loam
Textural characteristics						
pH in water	6.0	6.56	5.40	5.30	6.20	6.30
pH in 0.01M $CaCl_2$	5.2	4.90	4.84	4.84	5.10	4.80
Organic carbon (gkg^{-1})	12.40	4.00	9.60	4.00	6.00	4.28
Total N (gkg^{-1})	0.35	0.54	1.10	0.52	1.33	1.24
Available P ($mgkg^{-1}$)	7.13	1.78	6.20	8.40	17.50	7.00
Exchangeable bases ($Cmolkg^{-1}$)						
Ca	0.56	0.98	1.08	0.42	0.37	0.93
Mg	0.45	1.15	0.63	0.41	1.17	2.36
K	0.23	0.26	0.18	0.27	0.17	0.19
Na	0.47	0.22	0.54	0.43	0/33	0.37
Exchangeable acidity (H+Al)	0.20	0.20	0.20	0.20	0.18	0.18
CEC	6.80	13.00	8.60	7.20	8.40	12.50

DM accumulation as influenced by the N, P and FYM rates is presented in Table 2. Application of both rates of N resulted in similar but significantly ($P<0.05$) higher TDM production over the control in 2005 and combined data, while in 2006 and 2007, each increase in N rate led to a significant increase in DM accumulation. The positive influence of N on TDM could be due to its role in promoting rapid vegetative growth and its direct effect on cell division, expansion and synthesis of enzymes and chlorophyll (Brady and Weil, 2004). The application of both rates of FYM resulted in comparable but significantly ($P<0.05$) high DM accumulation over plots with no manure treatments (Table 2). The positive influence of FYM on TDM could be attributed to the ability of manure to improve soil physical condition and supply of essential nutrients required for vegetative growth (Eghball 2002; Anon, 2007 and Bationo *et al.,* 2007).

Table 2: Total DM of Roselle as influenced by N, P and FYM rates at various seasons

Treatments	Seasons			
	2005	2006	2007	Mean
N (KgNha^{-1})				
0	56.7	82.5c	50.9c	61.3b
60	67.0	106.7b	75.8b	80.6a
120	75.6	119.4a	86.2a	90.3a
SE±	5.34	4.65	2.97	4.32
P (Kg P ha^{-1})				
0	76.7	110.4	73.1	86.7
13.2	75.5	121.0	72.3	89.6
26.4	74.1	119.4	67.6	87.0
SE±	5.34	4.65	2.97	4.32
FYM (t ha^{-1})				
0	56.2b	98.0b	63.3b	70.3
5	82.1a	129.3a	73.2a	94.9a
10	88.0a	123.5a	76.4a	96.0a
SE±	4.48	3.61	2.14	3.41
Interaction				
NxP	NS	NS	NS	NS
NxM	NS	NS	**	NS
PxM	NS	NS	NS	NS
NxPxM	NS	NS	NS	NS

Means followed by unlike letter(s) within a treatment group column differ significantly using DMRT (P=0.05). NS=Not significant, **=Significant at P=0.01

P application had no significant (P<0.05) effect on DM production in all the years of study and even their combined effect (Table 2), probably because unlike N, it doesn't promote aerial vegetative growth of most crops. It could also be linked to the presence of appreciable amount of P in the experimental soils especially in 2007 season (Table I).

The influence of N and FYM interaction on DM accumulation is shown in Table 3. The application of 120 Kg N ha^{-1} with either rates of FYM maximized DM production in Roselle. The significant and positive effect of an interaction between N and FYM on DM production further affirmed the critical roles of N and FYM in promoting growth and DM accumulation, and the complementarity of using both on crops (Quinones, *et al.,* 1997; Bationo, 2008).

Table 3: TDM of roselle as influenced by significant interaction between N and FYM in 2007

	FYM (t ha^{-1})		
	0	5	10
N (KgNha^{-1})			
0	48.1c	51.0c	53.5c
60	73.5b	76.5b	77.5b
120	68.4b	92.2a	98.1a
SE±		4.24	

Means followed by different letter(s) within a set of interaction differ significantly using DMRT (P=0.05)

Applied N reduced K and Mg, and only increased Ca concentration in 2007, while the uptake of all the cations by Roselle was increased following N application (Tables 5, 6 and 7). The reduction of K and Mg probably resulted from the increased demand for them with N application which enhanced the growth of the crop. Similarly, because of increased demand for these nutrients more growth stimulated nutrient uptake.

According to Brady and Weil (2004) provision of sufficient quantities of N encouraged rapid vegetative growth and regulates the uptake of K and other nutrients from the soil. P application increased K and Mg but reduced Ca concentration in shoots (Tables 4, 5 and 6). The increase in K and Mg contents by provision of sufficient quantities of N encouraged rapid vegetative growth and regulated the uptake of K and

Table 4: Potassium content (%) and uptake (g plant^{-1}) as influenced by N, P and FYM rates at Samaru during 2005, 2006 and 2007 wet seasons.

	Potassium (%)				Potassium (g plant-1)			
Treatments	2005	2006	2007	mean	2005	2006	2007	mean
N (KgNha^{-1})								
0	0.64	1.14a	0.89a	0.89a	0.38	0.62b	0.42b	0.61c
60	0.67	1.02	0.85b	0.85b	0.47ab	1.25b	0.63a	0.78b
120	0.65	1.14a	0.84b	0.88	0.58a	1.62a	0.70a	0.97a
SE±	0.027	0.041	0.028	0.012	0.040	0.081	0.040	0.033
P (KgPha^{-1})								
0	0.65	1.07	0.85b	0.86b	0.46	1.19	0.57	0.74
13.2	0.63	1.08	0.84b	0.85b	0.47	1.35	0.59	0.80
26.4	0.67	1.15	0.89a	0.90a	0.51	1.34	0.9	0.81
SE±	0.027	0.041	0.028	0.012	0.040	0.081	0.040	0.033
FYM (t ha^{-1})								
0	0.66a	1.18a	0.87	0.91a	0.37b	1.19	0.52b	0.69b
5	0.63b	1.06b	0.86	0.85b	0.45b	1.33	0.62a	0.80a
10	0.66a	1.07b	0.85	0.86b	0.61a	1.37	0.62a	0.87a
SE±	0.027	0.039	0.028	0.011	0.023	0.047	0.023	0.019
Interaction								
NxP	NS	NS	NS	NS	NS	NS	NS	NS
NxM	NS	NS	NS	NS	NS	NS	NS	NS
PxM	NS	NS	NS	NS	NS	NS	NS	NS
NxPxM	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by unlike letter(s) within a treatment group and column differ significantly using DMRT (P=0.05). NS= Not significant

Table 5: Shoot calcium content (%) and its uptake as influenced by N, P and FYM rates in 2005, 2006 and 2007 wet seasons

	calcium (%)				calcium (g plant^{-1})			
Treatments	2005	2006	2007	mean	2005	2006	2007	mean
N (KgNha^{-1})								
0	1.42	1.46	1.37b	1.42	0.81b	1.21c	0.69c	0.87c
60	1.44	1.45	1.40a	1.43	0.97a	1.55b	1.06b	1.15b
120	1.42	1.42	1.41a	1.42	0.81b	1.69a	1.22a	1.28a
SE±	0.012	0.023	0.006	0.015	0.007	0.027	0.005	0.013
P (KgP ha^{-1})								
0	1.45a	1.48a	1.43a	1.46a	1.11a	1.63b	1.04a	1.27a
13.2	1.39b	1.43ab	1.41b	1.42a	1.05b	1.73a	1.02b	1.27a
26.4	1.40b	1.42b	1.34c	1.38b	1.04b	1.69a	0.91c	1.20b
SE±	0.012	0.023	0.006	0.015	0.007	0.027	0.005	0.013
FYM (t ha^{-1})								
0	1.44b	1.41b	1.45a	1.43a	0.81b	1.38b	0.91b	1.01b
5	1.48b	1.41b	1.37b	1.39b	1.22a	1.82a	1.02a	1.32a
10	1.50a	1.51b	1.36b	1.44a	1.32a	1.86a	1.04a	1.38a
SE±	0.006	0.008	0.002	0.005	0.004	0.011	0.002	0.004
Interaction								
NxP	NS	NS	NS	NS	NS	NS	NS	NS
NxM	NS	NS	NS	NS	NS	NS	NS	NS
PxM	NS	NS	NS	NS	NS	NS	NS	NS
NxPxM	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by unlike letter(s) within a treatment group and column differ significantly using DMRT (P=0.05). NS= Not significant

Table 6: Shoot Mg content (%) and uptake (g plant^{-1}) as influenced by N, P and FYM rates in 2005, 2006 and 2007 wet seasons

	Magnesium (%)				Magnesium (g plant^{-1})			
Treatments	2005	2006	2007	mean	2005	2006	2007	Mean
N (KgNha^{-1})								
0	0.82	0.92	0.85	0.87a	0.47c	0.76c	0.43c	0.53c
60	0.79	0.92	0.80	0.84b	0.53b	0.98b	0.61b	0.68b
120	0.84	0.97	0.85	0.89a	0.64a	1.16a	0.73a	0.80a
SE±	0.026	0.031	0.026	0.010	0.019	0.036	0.022	0.008
P (Kg P ha^{-1})								
0	0.81	0.93	0.83	0.86b	0.62	1.03	0.61	0.75
13.2	0.79	0.92	0.81	0.84b	0.60	1.11	0.59	0.75
26.4	0.84	0.96	0.86	0.89a	0.62	1.15	0.58	0.77
SE±	0.026	0.031	0.026	0.010	0.019	0.036	0.022	0.008
FYM (t ha^{-1})								
0	0.81	0.95	0.82	0.86	0.46c	0.93c	0.52b	0.61b
5	0.82	0.93	0.85	0.86	0.67b	1.20a	0.62a	0.82a
10	0.82	0.93	0.84	0.86	0.72a	1.15b	0.64a	0.83a
SE±	0.009	0.010	0.009	0.003	0.007	0.013	0.007	0.003
Interaction								
NxP	NS	NS	NS	NS	NS	NS	NS	NS
NxM	NS	NS	NS	NS	NS	NS	NS	NS
PxM	NS	NS	NS	NS	NS	NS	NS	NS
NxPxM	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by unlike letter(s) within a treatment group and column differ significantly using DMRT (P=0.05). NS= Not significant

other nutrients from the soil. P application increased K and Mg but reduced Ca concentration in shoots (Tables 4, 5 and 6). The increase in K and Mg contents of shoots could be due to increased development of root system by P, which encouraged the utilization of more nutrients and moisture from the soil (Brady and Weil, 2004).

The decrease in Ca content as Mg content increased in shoots probably corroborates the mutual antagonisms reported between Ca and Mg in plant tissues by Jones (2003) in plant tissues. The uptake of K and Mg by Roselle were, however, not influenced by P application. The effect of applied P on potassium and magnesium indicated that there were adequate amounts of these nutrients in the plants while the increased Ca uptake may be ascribed to increased demand for it especially for subsequent reproductive phases of the crop. The effect of FYM treatments on the contents and uptake of K, Ca and Mg are shown in Tables 4, 5 and 6. The decreases in K and Ca contents of Roselle shoots could be attributed to increased respiratory process and dilution effect resulting from increased growth activities following the application of FYM.

On the other hand, the uptake of K, Ca and Mg were enhanced by manure application (Tables 4, 5 and 6). This result conforms to similar findings, that humic acid released from manure decomposition increased respiratory process, hormonal growth responses, chlorophyll content, uptake of nutrients and growth activities (Tekwa et al, 2010). It could also be attributed to the favorable soil physical conditions and increased availability of nutrients through the process of manure mineralization (Egball, 2002 and Bationo, 2007).

CONCLUSION

Based on the result, application of 60 kg N ha^{-1} and 5 t FYM ha^{-1} increased DM production in Roselle, while the effect of P applications was not significant, statistically (P<0.05). However, application of 60 kg N reduced both K and Mg contents, but had no influence on Ca content in the Roselle shoots. Instead, the uptake of K, Ca and Mg increased linearly with N application rates. Likewise, the application of 26.4 kg P ha^{-1} increased K and Mg, but reduced both the content and uptake of Ca in Roselle, It however, did not exert significant (P<0.05) effect on Mg uptake. It was also observed that both K and Ca contents were reduced by the application of 5 t FYM ha^{-1}. This FYM rate did not affect Mg content in the Roselle, but significantly (P<0.05) increased the uptake of all the nutrients in the plant during the research.

RECOMMENDATIONS

It is recommended that 60 kg N ha^{-1} and 5 t FYM ha^{-1} are adequate for DM production in Roselle plants. However, a further trial at higher rates of N application is recommended for Roselle production in the study area.

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