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NITROGEN UPTAKE IN COW DUNG AND POULTRY MANURE TREATED MAIZE (*Zea mays* L.) UNDER DIFFERENT IRRIGATION INTERVALS IN SUDAN SAVANNA ECOLOGY, SOKOTO, NIGERIA

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ABSTRACT

Field trials were conducted at the Usmanu Danfodiyo University Teaching and Research Vegetable farm, Sokoto in 2018 and 2019 dry seasons to evaluate the effect of irrigation intervals, manure types and rates on nitrogen uptake in maize. The treatments consisted of four irrigation intervals (3, 6, 9 and 12 days), two manure types (cow dung and poultry manure) applied at four rates (0, 2.5, 5 and 7.5t/ha). The experiment was laid in split-split design replicated three times. Data on the dry matter content and percentage nitrogen content of stover and grains were collected for obtaining the maize N uptake. Data generated were subjected to analysis of variance (ANOVA) using statistix 10.0 statistical package. The results obtained indicated that the treatments significantly ($P<0.05$) influenced the uptake of nitrogen in maize. Increasing irrigation days interval reduced N uptake considerably which had negative effect on the overall yield of maize. Poultry manured maize absorbed higher nitrogen relative to cow dung and the amount of N absorbed increased with increasing rate of manure application. Conclusively, application of 7.5t/ha poultry manure under 3 days irrigation interval ensured greater N uptake of maize.

Keywords: Irrigation intervals; Manure types; Nitrogen uptake; Maize

INTRODUCTION

Among the major plant nutrients applied to maize (*Zea mays* L.), nitrogen (N) is the most critical. Maize plants grown under limited N supply showed stunted growth, yellowish leaves, and reduced yield. However, while supplemental N fertilizer application can prevent N stress and increase yield, excess N can result in contamination of ground and surface waters (Mehdi and Madramootoo, 1999; Lehrsch *et al*., 2000; Yang *et al.*, 2012). Therefore, it is desirable to maintain an optimum maize N status to match plant uptake (Yang *et al.*, 2012).

Crops often take up less than half the amount of N applied, while the rest is lost as gaseous nitrous oxide emissions and nitrate leaching or added to soil organic matter, which reduces N use efficiency in agricultural systems (Bouwman *et al*., 2002; Sehy *et al*., 2003; Liu *et al*., 2013; Zhang *et al*., 2015; Ngosong *et al*., 2019**)**. The rate of N uptake of crops is highly variable during crop development and between years and sites. However, under ample soil N availability, crop N accumulation is highly related to crop growth rate and to biomass accumulation (Gastal and Lemaire, 2002). Application of livestock manure with a high carbon-to-N ratio can lead to N immobilization in the soil, thereby restricting maize N uptake and potent yield in the short-term (Nyamangara *et al*., 2003).

Nitrogen uptake is influenced by different fertilization material and methods and plays an important role in maize growth and grain yield (Geng *et al*., 2019). Many studies have shown that the application of manure can increase maize yields and N uptake, decrease NO_3^- - N accumulation in the soil, restore crop productivity and sustainability, and reduce the apparent N surplus (apparent N surplus = applied fertilizer N – N uptake in the crop) (Hoa *et al*., 2008; Bi *et al*.; Wen *et al*., 2016; Geng *et al*., 2019). Moisture affects nitrogen nutrition through its influence on nitrogen uptake, on mineralization of organic nitrogen losses such as denitrification of volatilization. The final distribution of added N throughout the plant and the soil's mineral-N, organic-N system are, thus, markedly affected by the soil moisture regime (Paul and Myers, 1970).

This research was therefore carried out to evaluate the effect of irrigation regime, manure types and their rates on the nitrogen uptake in maize.

MATERIALS AND METHOD

The study was conducted during 2018 and 2019 dry seasons at the Usmanu Danfodiyo University, Vegetable Research Farm (latitude; 13º05'37.374" N longitude; 5º12'35.849" E) located at Kwalkwalawa village, in Dundaye District of Sokoto state. The treatments consisted of four (4) irrigation intervals (3, 6, 9 and 12 days) and two (2) manure types (cow dung and poultry droppings) applied at four (4) different rates (0, 2.5, 5, 7.5 t/ha). The experiment was laid out in a split - split plot design replicated three times. Irrigation treatments (irrigation intervals) were assigned to the main plots, manure types (cow dung and poultry droppings) to the sub plots while manure rates were assigned into the sub-subplots.

At harvest, three (3) out of the five (5) tagged plants in each experimental plot (sub-subplot) were destructively sampled and enveloped separately. The sampled plants were quickly washed, weighed and oven dried at 70ºC to a constant weight (to obtain the dry matter accumulation in kilogram per hectare). The weight of the sampled plants was then multiplied to the number of plants counted during establishment count and was further extrapolated to hectare basis. The straw and grains were ground separately and sampled for total nitrogen determination using Kjedahl wet digestion and distillation method as describe by Soil Survey Staff (1999). The data generated (dry weight, total N concentration) were used to compute N-uptake using the formula reported by Sharma *et al*. (2012):

$$\text{N-Uptake(kg/ha)} = \frac{\text{Percentage N concentration in straw and grain} \times \text{Dry matter (kg/ha)}}{100}$$

Data generated were subjected to analysis of variance (ANOVA) using statistix 10.0 statistical package, where significant difference among treatment mean was observed LSD was used for mean separation.

RESULTS AND DISCUSSION

The effects of irrigation interval, manure types and rates on the N – uptake of maize in 2018 and 2019 dry seasons and the combined are presented in Table 2. The results indicated that irrigation intervals significantly ($P<0.05$) affected N – uptake, where N concentration (uptake) of maize irrigated at 3 and 6 days intervals were statistically similar and were comparably higher in both years of trial and the combined. The lowest N uptake was in maize irrigated at 9 and 12 days intervals. This was apparently due to adequate moisture (3 and 6 days irrigation intervals), which is invariably a factor for better plant nutrient absorption and assimilation. At 9 and 12 days irrigation intervals, soil moisture was at 2.5 and 2% (Table 1) volumetric moisture content respectively. Paul and Myers (1970) reported that increased moisture stress depressed N – uptake in the loamy soils but have no obvious effect in clay soils. Abreu *et al*., (1973) stated that nitrogen uptake and distribution in wheat (*Triticum aestivum*) were dependent on environmental condition and particularly on the water regime. Mean N – uptake values ranged from 131.6 to 164 kg/ha in response to irrigation scheduling.

Table 1: Effect of irrigation treatments on soil moisture level

Irrigation Treatment (Days interval)	Moisture content (% Volumetric)
0 (saturation)	48.77
3	17.72
6	5.51
9	2.52
12	2.18

Table 2: Effect of irrigation intervals, manure types and rates on the N – Uptake of maize (kg/ha N) in 2018, 2019 dry seasons and the combined

Irrigation intervals (days)	2018	2019	Combined
3	140.76[a]	187.10[a]	163.93[a]
6	128.79[ab]	183.41[a]	156.10[a]
9	119.56[bc]	161.34[b]	140.45[b]
12	107.80[c]	155.33[b]	131.57[b]
SE±	4.879	4.240	4.435
CV	16.89	14.68	15.36
	Manure types		
Cow dung	107.69[b]	147.20[b]	127.44[b]
Poultry droppings	140.77[a]	196.39[a]	168.58[a]
SE±	2.079	2.178	1.721
CV	4.79	5.02	3.97
	Manure rates (t/ha)		
0	65.64[d]	91.87[d]	78.75[d]
2.5	116.90[c]	156.55[c]	136.73[c]
5	140.90[b]	199.16[b]	170.03[b]
7.5	173.48[a]	239.60[a]	206.54[a]
SE±	5.060	3.25	3.32
CV	13.47	8.66	8.84

Means in a column and treatment group followed by same letters are not significantly different using Turkey HSD at 5% level. * = Significant at 5% level of probability.

N – uptake in maize was affected significantly ($P<0.05$) by manure types, where application of poultry droppings recorded the highest concentration of N (uptake) than with cow dung (Table 2). These results have demonstrated that nutrient availability enhance nutrient absorption. This result agrees with the report by Nwite and Alu (2018) who observed a significant (P<0.05) increase in soil chemical properties due to poultry manure application. The authors reported that plots amended with 40 t/ha poultry manure had significantly higher nitrogen compared to other treatments. Many studies have shown that application of manure can increase maize yield and N – uptake, decrease NO_3^- - N accumulation in the soil, restore soil productivity and sustainability, and reduce the apparent N surplus (apparent N surplus = applied fertilizer – N uptake in the crop). (Hoa *et al*., 2008; Bi *et al*., 2009; Wen *et al.* 2016; Geng *et al*., 2016). Similarly, Wen *et al*. (2016) reported that manure application significantly increased maize grain yield and N – uptake of maize.

Significant variation was recorded on the N – uptake due to different levels of applied manures (Table 2). The result revealed that application of 7.5 t/ha yielded the highest N concentration in plant while the least was in where manure was not applied. N – uptake values as influenced by manure rates ranged from 78.8 to 206.5 kg/ha, with uptake increasing consistently with increase in rate.

Interaction Effects

Interaction effects between irrigation intervals and manure types on N – uptake in maize in 2018 and 2019 and the combined are presented in Table 3. The result indicated that interaction between irrigation and manure types significantly (P<0.05) affected N - Uptake, where application of poultry droppings and irrigation interval of 3 and 6 days gave the higher N - uptake, with values of 154 and 148 kg N/ha respectively.

Table 3: Interaction effect between irrigation intervals and manure types on the N – Uptake of maize (kg/ha) in 2018, 2019 dry seasons and the combined

Irrigation interval (days)	Manure types	
	Cow dung	Poultry droppings
	2018	
3	127.20	154.34
6	109.68	147.91
9	100.85	138.27
12	93.03	122.57
SE±	4.15	
CV	16.45	
	2019	
3	157.21[bc]	216.98[a]
6	150.56[c]	216.26[a]
9	143.83[c]	178.84[b]
12	137.20[c]	173.47[b]
SE±	4.35	
CV	17.23	
	Combined	
3	142.20[bcd]	185.65[a]
6	130.12[cde]	182.09[a]
9	122.34[de]	158.55[b]
12	115.12[e]	148.02[bcd]
SE±	3.44	
CV	13.62	

The values decreased consistently at 9 and 12 days intervals. The least uptake was observed with the application of cow dung at 12 days irrigation intervals. The results strengthen the opinion that good quality manure under sufficient moisture levels will stimulate higher N absorption by plants and therefore better crop performance. It is well documented that movement of N within the soil system to the root of plants is through mass flow and therefore, available moisture is a factor for N movement to the root surfaces and consequent uptake.

Interaction effects between irrigation intervals and manure rates on the N – uptake of maize in 2018 and 2019 dry season and the combined are presented in Table 4. The results indicated that interaction between irrigation intervals and manure rates significantly ($P<0.05$) affected N – Uptake of maize. The 7.5 t/ha at 3 and 6 days irrigation intervals, promoted the highest N uptake in maize relative to the other treatments. The 5 t/ha at 3 and 6 days irrigation interval treatments were also equally effective. The least N uptake recorded was with zero manure application, at all the irrigation interval (3, 6, 9 and 12days). These results obtained here could be attributed to the role of sufficient nutrients levels in attaining the optimum plant physiological demand. N - Uptake increased with increase in manure rates and in irrigation frequency.

Table 4: Interaction effect between irrigation intervals and manure rates on the N – Uptake of maize (kg/ha N) in 2018, 2019 dry seasons and the combined

Irrigation interval (days)	Manure rates (t/ha)			
	0	2.5	5	7.5
		2018		
3	72.2^{ef}	123.62^{d}	164.39^{abc}	200.80^{a}
6	64.61^{f}	121.44^{d}	146.03^{bcd}	183.10^{a}
9	64.24^{f}	115.14^{d}	131.01^{cd}	167.86^{ab}
12	59.48^{f}	107.40^{de}	122.16^{d}	142.16^{bcd}
SE±		10.12		
CV		36.54		
		2019		
3	88.36^{g}	164.32^{def}	226.13^{b}	268.14^{a}
6	91.84^{g}	163.99^{def}	203.16^{bc}	274.65^{a}
9	97.48^{g}	151.77^{ef}	188.04^{cd}	208.06^{bc}
12	88.36^{g}	146.14^{f}	179.29^{cde}	207.54^{bc}
SE±		6.50		
CV		23.49		
		Combined		
3	82.00^{g}	143.97^{ef}	195.26^{b}	234.47^{a}
6	78.22^{g}	142.71^{ef}	174.59^{bcd}	228.87^{a}
9	80.86^{g}	133.45^{f}	159.53^{cde}	187.96^{b}
12	73.92^{g}	126.77^{f}	150.72^{def}	174.85^{bc}
SE±		6.64		
CV		23.98		

Interaction effects between manure types and levels on the N – Uptake of maize in 2018, 2019 and the combined are presented in Table 5. The interaction between manure types and rates significantly ($P<0.05$) affected N – uptake in maize in both years and the combined.

The highest N – concentration was due to application of poultry droppings at 7.5 t/ha (198.4 kg N/ha). Generally, N uptake increased with rates for both manure types and was consistently least with cow dung application.

Table 5: Interaction effect between manure types and rates on the N – Uptake of maize (kg/ha) in 2018/19, 2019/20 dry seasons and combined

Manure rates (t/ha^{-1})	Manure types (t/ha)	
	Cow dung	Poultry droppings
	2018	
0	66.59[e]	64.68[e]
2.5	90.75[d]	143.05[bc]
5	124.82[c]	156.98[b]
7.5	148.60[b]	198.36[a]
SE±	7.15	
CV	22.67	
	2019	
0	95.93[f]	87.80[f]
2.5	130.94[e]	182.16[cd]
5	169.76[d]	228.56[b]
7.5	192.17[c]	287.03[a]
SE±	4.60	
CV	14.57	
	Combined	
0	81.26[f]	76.24[f]
2.5	110.85[e]	162.61[c]
5	147.29[d]	192.77[b]
7.5	170.38[c]	242.69[a]
SE±	4.69	
CV	14.88	

The three way interaction effects of irrigation intervals, manure types and rates on the N – uptake of maize in 2019 and the combined are presented in Table 6. The results indicate that combined effect of irrigation interval, manure types and rates significantly ($P<0.05$) influenced N – uptake in maize. The application of 7.5 t/ha poultry droppings amended maize plots at 3 and 6 days irrigation intervals, recorded the maximum absorbed N than the other treatment combinations. The least N – uptake were in control plots irrigated at 12 days interval. The most promising combination was poultry droppings applied at 7.5 t/ha under 6 days irrigation interval (284 kg/ha N uptake).

Table 6: Interaction effect between irrigation intervals, manure types and rates on the N– Uptake of maize (kg/ha N) in 2018, 2019 dry seasons and combined

Irrigation interval (days)	Manure types								
	Cow dung (t/ha)					Poultry Droppings (t/ha)			
	0	2.5	5	7.5		0	2.5	5	7.5
					2018				
3	70.21	106.72	152.76	179.09		78.23	140.52	176.02	222.51
6	67.65	92.07	127.10	151.89		61.56	150.81	164.95	214.31
9	63.17	84.52	116.43	139.31		65.31	145.76	145.59	196.41
12	65.34	79.70	102.97	124.12		53.63	135.10	141.34	160.19
SE±					14.31				
CV					57.42				
					2019				
3	92.89^{j}	141.90^{g-i}	178.10^{e-f}	215.95^{cd}		86.70^{j}	186.75^{d-f}	274.15^{b}	320.33^{a}
6	97.56^{j}	137.64^{g-i}	171.66^{e-f}	195.36^{c-f}		86.12^{j}	190.33^{d-f}	234.67^{bc}	353.94^{a}
9	101.90^{ij}	123.50^{h-j}	170.80^{e-f}	179.13^{d-g}		93.06^{j}	180.04^{d-g}	205.29^{c-e}	236.99^{bc}
12	91.37^{j}	120.73^{ij}	158.46^{f-h}	178.23^{d-g}		85.34^{j}	171.54^{e-g}	200.13^{c-e}	236.86^{bc}
SE±					9.20				
CV					36.91				
					Combined				
3	81.55^{dk}	124.31^{f-i}	165.43^{c-e}	197.52^{bc}		82.46^{jk}	163.63^{c-e}	225.09^{b}	271.42^{a}
6	82.61^{i-k}	114.86^{g-j}	149.38^{d-g}	173.62^{c-e}		73.84^{k}	170.57 $^{c-e}$	199.81^{bc}	284.12^{a}
9	82.54^{i-k}	104.01^{h-k}	143.61^{d-g}	159.22^{c-f}		79.19^{jk}	162.90^{c-f}	175.44^{cd}	216.70^{b}
12	78.36^{jk}	100.22^{h-k}	130.72^{e-h}	151.17^{d-g}		69.49^{k}	153.32^{d-g}	170.73^{c-e}	198.53^{bc}
SE±					9.39				
CV					37.69				

CONCLUSSION

Irrigation interval, manure types and rates had significant influence on the uptake of nitrogen by maize. N uptake increased significantly with increasing soil moisture level and was higher in poultry manure treated maize than cow dung. Rate of manure application was proportional to N uptake level. Highest N uptake was due to combined effects of poultry manure at 7.5t/ha on soil irrigated at 3 or 6 days interval.

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