http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 16 (2): 51-58, 2013
ISSN 1028-8880 / DOI: 10.3923/pjbs.2013.51.58

Effects of Irrigation Regime, Organic and Inorganic Mineral Source on Growth and Yield Components of Switchgrass (*Panicum virgatum* L.) in Upland and Lowland Conditions in Sokoto, Nigeria

[1]A.A. Abdullahi, [2]B.L. Aliero, [2]A.A. Aliero and [3]A.A. Zuru
[1]Department of Biology, Shehu Shagari College of Education, Sokoto, Nigeria
[2]Department of Biological Sciences, Usmanu Danfodiyo University, Sokoto, Nigeria
[3]Department of Pure and Applied Chemistry, Usmanu Danfodiyo University, Sokoto, Nigeria

Abstract: The effects of organic, inorganic fertilizer and irrigation regime on yield parameters of *P. virgatum* in upland and lowland areas in Sokoto geoecological region of Nigeria were assessed. Four levels of nitrogen (0, 25, 50 and 75 kg N ha^{-1}), three rates of farmyard manure (0, 5 and 10 t ha^{-1}) and three irrigation regimes (w_2, w_4 and w_6) were set up as a split -plots design. Farmyard manure and irrigation regimes were combined and allocated as the main plots, while nitrogen rates were assigned to the sub-plots and each replicated three times. Results revealed that raising nitrogen rate from 50 to 75 kg N ha^{-1}, farmyard manure rate from 5-10 t ha^{-1} or irrigation intervals from 2 to 4 days did not show a significant ($p>0.05$) increase in yield components evaluated. Dry matter accumulation was significantly ($p<0.05$) affected by irrigation regime in both seasons and locations and 2 day interval irrigation had the highest dry matter yield. A significant interaction between nitrogen and manure application was observed only at upland in 2008/2009 and a combination of 75 kg N ha^{-1} and 10 t ha^{-1} manure produced the highest values in all the parameters evaluated. The study suggest that 50 kg N ha^{-1} with 5 t ha^{-1} of farmyard manure and 2 day irrigation interval gave the highest yield. A combination of 50 kg N ha^{-1}, with 5 t ha^{-1} of farmyard manure and 2 day irrigation interval were found to be optimum for growth and yield of Switchgrass under both lowland and upland conditions in Sokoto geoecological zone of Nigeria.

Key words: Switchgrass, irrigation, farmyard manure, nitrogen fertilizer, yield

INTRODUCTION

Switchgrass (*Panicum virgatum* L.) is a perennial grass native to North America, where it occurs naturally from 55° N in Canada, United States and Mexico. It is one of the dominant species of the Central North American tall grass prairies used primarily for soil conservation (USDA and NRCS, 2008), forage production (Stegelmeier *et al*., 2007), game cover (Bies, 2006), as an ornamental grass (Samson, 2007) and more recently as a biomass crop for ethanol, fiber, electricity and heat production (REAP, 2004; Samson *et al*., 2005; Hastings and Prince, 2007). Switchgrass can yield a variety of useful fuels such as synthetic gasoline and diesel fuel, methanol methane gas, hydrogen as well other chemical by- products useful for making fertilizers, solvents and plastics (Bransby, 2005). Current research on switchgrass biomass production has largely evaluated switchgrass adaptability on small-scale plots in varying environments (Casler *et al*., 2004, 2007). However, the potential of switchgrass as a biofuel feedstock in Nigeria has not been exploited. There is currently no information on the potential impact of large-scale switchgrass growth and production on the natural resources and the environment. For example, uncertainly surrounds the effective use of water by the crop and, the lack of information on the basic agronomies dictated that research be undertaken to develop a capacity for predicting impacts of large-scale planting of switchgrass in Nigeria.

Nitrogen availability is one of the most crucial factors in determining crop yield (Carpenter-Boggs *et al*., 2000) and it increases the population of soil microorganisms (Ladd *et al*., 1994; Smolander *et al*., 1994; Entry *et al*., 1996). Franzluebber *et al*. (1998) suggested that an integrated soil fertility management practice, which incorporates organic and inorganic sources, is needed to increase the productivity of low activity clay soils. Organic N sources, in addition to supplying nutrients, also improve soil condition, reduce temperature, conserve soil and reduce erosion (Tian *et al*., 2000). A deficiency of nitrogen results in yellowing of leaves, slow and stunted growth and excess nitrogen may increase crop susceptibility to pest and disease attack (Amans *et al*.,

Corresponding Author: A.A. Aliero, Department of Biological Sciences, Usmanu Danfodiyo University, Sokoto, Nigeria

1990; Brice *et al*., 1997). Supplemental irrigation is used to argument the shortfall in rainfall that occurs during the growing season. Irrigation is used on full season agronomic crops to provide a dependable yield every year. It is also used on crops where water stress affects the quality of the yield which brings increased yield and allows double cropping and intercropping. In addition to increased yield of forage crops, irrigation intensifies crop production by creating favourable conditions for the growing of vegetables, forage crops, planting materials, fruits and flowers as well as for seed production (Thomson, 1996).

Growing and developing perennial forage crops such as switchgrass as biofuels could benefit the national economy by providing an important new source of income for farmers (McLaughlin *et al*., 1999). In addition, energy production from perennial cropping systems, which are compatible with conventional farming practices, would help reduce degradation of agricultural soils, lower national dependence on fossil fuels and reduce emissions of green house gases and toxic pollutants to the atmosphere as well as less displacement of land for food production or loss of biodiversity through habitat destruction. Switchgrass when grown in large quantity can effectively be utilised to promote its use in soil conservation, biofuel production and generate employment in the rural communities of Nigeria. This research could help in promoting higher biomass productivity which will serve as feedstock to bio-refineries and address energy requirements. On the long-run, it is envisaged that this research will give impetus to the construction of bio-refineries in Nigeria. The objectives of this work are to investigate the effects of organic, inorganic nutrients and varying irrigation regimes on growth and yield parameters of switchgrass.

MATERIALS AND METHODS

Collection of materials and experimentation: Seeds of switchgrass were sourced from the United State of America (USA) through Sokoto Energy Research Centre, Usmanu Danfodiyo University, Sokoto, Nigeria on a Pure Live Seed basis (PLS). The seeds were kept in big labelled paper envelope and stored in metal cabinets in the University herbarium. Field experiments were conducted during 2008/2009 and 2009/2010 dry seasons at both upland and lowland areas. Sokoto is located on latitude 13^0. 01N and longitude 05^0. 15E and lies at an altitude of 350 m above sea level (Kowal and Knabe, 2002). The temperature averages ranges from 27-40°C in April and 18°C in December-January. The state falls in the Sudan savanna agro-ecological zone of Nigeria. Treatments consist of three rates of manure as farmyard manure (0, 5 and 10 t ha^{-1} fym), four rates of nitrogen fertilizer (0, 25, 50 and 75 kg N ha^{-1}) and three irrigation regimes (w_2, w_4 and w_6) for watering every two, four and six days respectively. The treatments were laid out in split-plot design and replicated three times. Manure rates and irrigation regimes were combined and allocated as the main plots, while nitrogen levels were assigned to the sub-plots. The gross plot size had a dimension of 4×3 m (12 m^2) consisting of 36 plots, the net plot size was ×2 m^2 (2 m^2) and the total area of the experimental sites was 10,000 m^2.

Experimental sites were ploughed, harrowed, levelled and plots demarcated manually. Seed beds of 4×3 m were prepared. Irrigation channels were laid out to convey water and drain away the excess. One meter leeway was left between blocks. Seeds were sown on 14th December, 2009 and 2010. The seeds were sown by direct seeding using a spacing of 1×1 m at 0.5-1.0 cm planting depth according to Ontario Ministry of Food Agriculture and Rural Affairs (OMAFRA) guidelines for forage crops. Five seeds were sown per hole and later thinned to 3 plants per hole.

Nitrogen fertilizer in form of urea (0, 25, 50 and 75 kg N ha^{-1}) was applied through ring application method in two equal doses according to the treatments, the first dose was applied after the first weeding (2 WAP), while the second dose was applied by top dressing (6 WAP). Different rates of farmyard manure (0, 5 and 10 t h^{-1}) as per treatment were applied during land preparation. The seedlings were subjected to 3 watering regimes i.e., W_2, W_4 and W_6 indicating watering every two, four and six days respectively. Weeding was carried out manually at two Weeks After Sowing (WAS) and subsequently after every two weeks to maintain weed free fields. The incidence of termite was controlled by applying chloropyriphos 20% EC insecticide at the base of the plant at the rate of 1250 mL per 500 L of water. Harvesting was done manually and was taken at the late boot stage of the development and tied into small bundles.

Data collection and analysis: Three plants were randomly tagged from the inner rows of each plot and were used for the evaluation of growth and yield parameters. Number of inflorescence was recorded by counting from the three tagged plants. The inflorescence count was taken at 13 WAS and the average count recorded. Days to 50% flowering were determined when 50% of the plants population in a particular treatment flowered. Number of seeds per plant was counted at harvest from the 3 tagged plants for each treatment. The seeds were threshed, counted and average per plant determined. Cumulative seed weight per plant was extrapolated to kg ha^{-1} times number of plant per hectare. Shoot and dry matter accumulation was taken at the end of the experiment, shoots of the plants were harvested. Fresh and dry weights were taken to estimate the dry matter accumulation. The shoots were placed on an oven Gallenkamp (Model IH-150) and dried at 70°C for 72 h. The dried materials were weighed separately on (Sartorius model P. 163) weighing balance. Data collected were analyzed using Statistical Package for Social Science (SPSS) version 16. Analysis of variance (ANOVA) was carried out and significant mean were separated using Duncan's New Multiple Range Test (DNMRT).

RESULTS

Effect of nitrogen, farmyard manure and irrigation regimes on number of inflorescence of switchgrass is presented in Table 1 and 2. Results revealed a significant effect ($p<0.05$) of nitrogen application on number of inflorescence. At lowland location and in both 2008/2009 and 2009/2010 growing seasons, the number of inflorescence per plant increased with increase in nitrogen rates. In 2008/2009, the highest number of inflorescence (58.26) was obtained in plants treated with 75 kg N ha^{-1} (Table 1). In 2009/2010 growing season N rates significantly affected the number of inflorescence (Table 2). At upland location in both seasons, control had the lowest number of inflorescence with 47.58 and 48.85 inflorescence per plant for the 2008/2009 and 2009/2010 growing seasons respectively. However, application of manure significantly ($p<0.05$) affected inflorescence number at both locations and seasons. A dose dependent response was observed with the application of manure with a resulting increase in the number of inflorescence per plant. Similarly, irrigation interval significantly affected ($p<0.05$) number of inflorescence in lowland location and for both years which increase with increase in the frequency of irrigation. The highest number of inflorescence was obtained in 2 days irrigation regime. However, there was no significant difference between the number of inflorescence per plots irrigated every 2 days and those irrigated after every 4 days in lowland location for both seasons. At upland in, 2008/2009 and 2009/2010, 2 days irrigation interval had the highest number of inflorescence per plant. A significant interaction beween nitrogen and manure application was observed only at upland in 2008/2009 (Table 2) and a combination of 75 kg^{-1} and 10 t ha^{-1} manure had the highest number of inflorescence.

The result on the effect of nitrogen, farmyard manure and irrigation regimes on number of seeds per plant is depicted in Table 1 and 2. Number of seeds per plant was significantly ($p<0.05$) higher in lowland location both in 2008/2009 and 2009/2010 growing seasons (Table 1, 2). It was observed that increasing N rate from 25 to 50 kg ha^{-1} increased number of seeds per plant. However, the values did not differ significantly with those obtained on the control treatment. The highest number of

Table 1: Effect of nitrogen, farmyard manure and irrigation regime on yield parameters of switchgrass at lowland and upland location in 2008/2009

	No. of inflorescence		No. of seeds per plant		Seed yield per hectare (kg)		Days to 50% flowering		Fresh weight (g)		Dry weight (g)	
Treatment	Lowland	Upland	Lowland	Upland	Lowland	Upland	Lowland	Upland	Lowland	Upland	Lowland	Upland
Nitrogen (kg ha^{-1})												
0	50.56^{c}	47.58	202.04^{b}	167.00	225.33^{b}	223.33^{b}	102.63^{c}	107.56^{c}	2.68^{c}	1.94^{b}	1.28	0.75
25	54.48^{b}	48.85	203.78^{ab}	168.19	305.67^{a}	302.00^{a}	106.00^{b}	110.93^{b}	3.08^{b}	2.39^{a}	1.35	0.98
50	54.96^{b}	50.26	205.11^{a}	171.04	327.00^{a}	326.33^{a}	108.00^{a}	113.19^{a}	3.42^{a}	2.47^{a}	1.36	0.99
75	58.26^{a}	50.04	204.44^{a}	171.37	316.33^{a}	315.67^{a}	108.15^{a}	113.44^{a}	3.42^{a}	2.49^{a}	1.37	0.99
SE±	1.00	0.85	1.09	2.28	0.52	0.51	0.27	0.29	0.12	0.12	0.10	0.13
Signifiance level	*	Ns	*	ns	*	*	*	*	*	*	ns	Ns
Manure (t ha^{-1})												
0	51.86^{b}	47.47^{b}	202.08^{b}	168.36	222.33^{b}	220.00^{b}	105.08^{b}	110.17^{b}	2.77^{b}	2.11	1.23	0.87
5	55.22^{a}	50.47^{a}	203.89^{a}	169.33	323.00^{a}	301.33^{a}	106.25^{a}	111.33^{a}	3.19^{a}	8.12	1.37	0.93
10	56.61^{a}	51.03^{a}	204.56^{a}	170.50	315.67^{a}	312.67^{a}	107.25^{a}	112.33^{a}	3.30^{a}	2.44	1.42	0.98
SE±	0.97	0.64	0.97	2.01	0.50	0.47	0.54	0.58	0.12	0.12	0.09	0.11
Significance level*		*	*	ns	*	*	*	*	*	Ns	ns	Ns
Irrigation regime												
2	55.81^{a}	50.97^{a}	204.72^{a}	170.72	329.00^{a}	324.00^{a}	106.08^{c}	111.00	3.39^{a}	2.71	1.56	1.11^{a}
4	54.83^{a}	49.58^{ab}	204.08^{a}	169.81	318.67^{a}	315.33^{a}	106.17^{b}	111.28	3.03^{b}	8.04	1.38	0.87^{b}
6	53.06^{b}	48.42^{b}	202.02^{b}	167.67	237.33^{b}	224.00^{b}	106.33^{a}	111.56	2.85^{b}	1.92	1.08	0.79^{b}
SE	1.05	0.70	0.96	2.00	0.48	0.50	0.58	0.61	0.12	0.12	0.08	0.11
Significance level*		*	*	ns	*	*	ns	ns	*	ns	ns	*
Interactions												
NxM	*	ns	ns	ns	ns	ns	*	*	ns	ns	ns	ns
NxI	ns	ns	ns	ns	ns	ns	*	ns	ns	ns	ns	ns
MxI	ns	ns	ns	ns	ns	ns	*	ns	ns	ns	ns	ns
NxMxI	ns	ns	ns	ns	ns	ns	*	ns	ns	ns	ns	ns

Means in a column with different superscripts are significantly different at $p<0.05$, *Significant at 5% levels, ns: Not significant. WAP: Weak after planting SE±: Standard error of means

Table 2: Effect of nitrogen, farmyard manure and irrigation regime on yield parameters of Switchgrass at lowland and upland location in 2009/2010

	No. of inflorescence		No. of seeds per plant		Seed yield per hectare (kg)		Days to 50% flowering		Fresh weight(g)		Dry weight(g)	
Treatment	Lowland	Upland	Lowland	Upland	Lowland	Upland	Lowland	Upland	Lowland	Upland	Lowland	Upland
Nitrogen (kg ha^{-1})												
0	51.52^{c}	48.85^{c}	203.93^{b}	165.04^{b}	237.33^{b}	224.67^{b}	103.19^{c}	108.04^{c}	2.92^{b}	2.23^{b}	1.30	0.76
25	53.85^{b}	50.59^{b}	204.93^{ab}	170.33^{a}	306.00^{a}	303.33^{a}	106.56^{b}	111.59^{b}	2.96^{b}	2.43^{a}	1.41	0.99
50	55.26^{a}	51.63^{ab}	206.26^{a}	172.33^{a}	318.67^{a}	315.00^{a}	108.56^{a}	113.26^{a}	3.53a	2.44^{a}	1.42	0.99
75	55.78^{a}	52.00^{a}	206.93^{a}	172.81^{a}	318.58^{a}	314.33^{a}	108.59^{a}	113.56^{a}	3.53a	2.45^{a}	1.42	1.00
SE±	0.41	0.64	0.99	2.97	0.52	0.50	0.30	0.29	0.12	0.14	0.09	0.12
Significance level*		*	*	*	*	*	*	*	*	*	ns	ns
Manure (t ha^{-1})												
0	52.25^{b}	48.92^{b}	203.92^{b}	165.69^{b}	223.67^{b}	221.00^{b}	105.56^{b}	110.50^{b}	2.96^{b}	2.22^{b}	1.35	0.86
5	54.17^{a}	51.06^{a}	205.58^{a}	171.81^{a}	313.00^{a}	304.35^{a}	106.81^{a}	111.72^{a}	3.25^{a}	2.49^{a}	1.38	0.94
10	54.89^{a}	51.33^{a}	206.03^{a}	172.39^{a}	324.33^{a}	314.33^{a}	107.81^{a}	112.61^{a}	3.24^{a}	2.60^{a}	1.43	1.01
SE±	0.51	0.61	0.89	2.57	0.50	0.48	0.54	0.54	0.12	0.12	0.08	0.11
Significance level*		*	*	*	*	*	*	*	*	*	ns	Ns
Irrigation regime												
222	54.58^{a}	51.42^{a}	206.25^{a}	172.42^{a}	329.67^{a}	326.33^{a}	106.17	111.31	3.37^{a}	2.79^{a}	1.57^{a}	1.12^{a}
4	54.11^{a}	50.81^{ab}	205.58^{a}	170.17^{a}	317.00^{a}	317.33^{a}	106.83	111.61	3.16^{a}	2.45^{b}	1.39^{b}	0.88^{b}
6	52.61^{b}	50.08^{b}	203.69^{b}	164.31^{b}	245.33^{b}	235.67^{b}	107.17	111.92	2.92^{b}	2.07^{c}	1.20^{c}	0.80^{b}
SE	0.52	0.61	0.89	2.60	0.48	0.51	0.58	0.58	0.12	0.10	0.07	0.10
Significance level*		*	*	*	*	*	ns	ns	*	*	*	*
Interactions												
NxM	ns	ns	ns	ns	ns	ns	*	*	ns	ns	ns	ns
NxI	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
MxI	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
NxMxI	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Means in a column with different superscripts are significantly different ($p<0.05$), *Significant at 5% levels, ns: Not significant, WAP: Weak after planting SE±: Standard error of means

seeds per plant were recorded with the highest nitrogen rate (75 kg ha^{-1}) in both years. The lowest number of seeds per plant was obtained with control in both 2008/2009 and 2009/2010 growing seasons. Increasing the nitrogen rates from 25 to 50 or 75 kg ha^{-1} was found to increase the seed number per plant. At the upland location in both 2008/2009 and 2009/2010 growing seasons, results revealed that increase in the N rate from 25 to75 kg ha^{-1} markedly increased number of seeds per plant.

Application of manure significantly ($p<0.05$) increase number of seeds in both seasons and locations. The lowest number of seeds per plant was obtained in the control treatments in the two seasons and the highest manure rate (10 t ha^{-1}) had the highest number of seeds per plant for both seasons and locations. Irrigation frequency significantly ($p<0.05$) increased number of seeds per plant at lowland location in both seasons. Two days irrigation interval had the highest number of seeds per plant in both 2008/2009 and 2009/2010 growing seasons. At upland location in both seasons similar trend were observed (Table 1, 2). Interaction between treatments was insignificant ($p<0.05$) on number of seeds per plant. Effect of nitrogen, farmyard manure application and irrigation regimes on seed yield per hectare is presented in Table 1 and 2. The effect of nitrogen application on seed yield per hectare was significant ($p<0.05$) at lowland location in 2008/2009 and 2009/2010 growing seasons (Table 1, 2). The highest yield was obtained with the application of 50 kg ha^{-1} in 2008/2009 and 2009/2010 seasons and the control had the lowest. In both seasons, the results indicate that there were no significant differences in seed yield for all the nitrogen levels (25, 50 and 75 kg ha^{-1}) even through plant treated with 50 kg ha^{-1} out-yielded the other two rates. At the upland location, similar trends were observed at different levels of nitrogen application for both 2008/2009 and 2009/2010 growing seasons (Table 1 and 2).

Seed yield was significantly ($p<0.05$) affected by manure rates at lowland location in both the growing seasons. Although, the highest rate of 10 t ha^{-1} manure gave the highest yield in 2009/2010, the different trend was observed in 2008/2009. In the 2009/2010 growing season, the highest seed yield of 323.00 kg ha^{-1} was obtain in plots treated with 5 t ha^{-1} of manure. At upland location in 2008/2009 and 2009/2010 growing seasons, results indicate a significant ($p<0.05$) increase in seed yield due to manure application. The result showed that increasing manure rate from 5 to 10 t ha^{-1} did not result in significant increases in seed yield. However, the values obtained for the seed yield from plots treated with manure differed significantly ($p<0.05$) from those obtained in the control (Table 1, 2). The effect of irrigation regime on seed yield was also significant ($p<0.05$) in both seasons and locations and the highest seed yield was obtained with two days irrigation interval. Interaction effect between treatments were insignificant (p>0.05) on seed yield at both locations and growing seasons.

Effect of nitrogen, farmyard manure application and irrigation regimes on days to 50% flowering is presented in Table 1 and 2. Results revealed that the effect of nitrogen on days to 50% flowering was significant (p<0.05). At the upland location in both 2008/2009 and 2009/2010 growing seasons, the control treatments had 50% flowering earlier than the nitrogen treated plots. However, there was no significant difference in the number of days to 50% flowering among treatments given 50 or 75 kg N ha^{-1}. The days to 50% flowering were at par for treatments that received 0 and 25 kg N ha^{-1} in both seasons. At upland in 2010, the trend was consistent with regards to days to 50% flowering, with higher nitrogen treatment (75 kg N ha^{-1}) being the last to attain 50% flowering and control trial being the first to reach 50% flowering. The result further showed that the effect of manure application variation in days to 50% flowering were significant in both seasons and locations. Plants that received the highest amount of manure (10 t ha^{-1}) were the last to reach 50% flowering in both seasons. At the upland location, similar trends were also observed in 2008/2009 and 2009/2010 growing seasons. With the application of 5 or 10 t ha^{-1} manure there were no significant differences in days taken to reach 50% flowering. Control plots were always the fist to reach 50% flowering days (Table 1, 2). Table 1 and 2 indicate that there were no significant differences in the days to 50% flowering among treatments that were irrigated for 2, 4 or 6 day interval in both locations and seasons. Interaction of nitrogen, manure and irrigation regime was significant (p<0.05) on days to 50% flowering at both lowland and upland location and in all the growing seasons (Table 3). The results indicated that a combination of no fertilizer, no manure and 2 day interval irrigation was the first to attain 50% flowering. This was followed by the same combination at 6 days irrigation interval. The combination of 10 t ha^{-1} manure, 75 kg N ha^{-1} and 6 days irrigation interval was the last to attain 50% flowering. This, however, did not differ significantly from the combination of 50 kg N ha^{-1}, 10 t ha^{-1} manure and 4 days irrigation interval.

The effect of nitrogen on fresh weight was significant (p<0.05) for both seasons (Table 1, 2). The highest mean fresh weight was recorded with 75 kg N ha^{-1} for the two growing seasons. However, there were no significant difference between treatments given 75 kg N ha^{-1} and treatments that received 50 kg N ha^{-1} in both growing seasons. At the upland location, the control treatment always recorded the least fresh weight with an average of 1.94 and 2. 23 g while the highest fresh weight was recorded with the highest nitrogen rates (75 kg N ha^{-1}) in both seasons. Manure effect was also found to be significant (p<0.05) in both seasons and locations (Table 1, 2). The highest fresh weight was recorded with the highest manure rate. Table 1 and 2 revealed a significant (p<0.05) effect of irrigation on the fresh weight of the plant at lowland location in both 2008/2009 and 2009/2010 seasons. It was observed that 2 day irrigation interval recorded the highest mean weight of individual plants which was not significantly different from 4 day irrigation interval. At the upland location in both seasons, successive increase in irrigation frequency brought about a significant increase in fresh weight. The highest fresh weight was recorded with 2 days irrigation interval in 2008/2009 and 2009/2010 growing seasons. Interaction effect between nitrogen, manure and irrigation on fresh weight of switchgrass at both locations and seasons was insignificant (p<0.05). Effect of nitrogen, farmyard manure application and irrigation regimes on dry weight is presented in Table 1 and 2. Results for 2008/2009 and 2009/2010 cropping seasons at both lowland and upland locations showed that the application of different levels of fertilizer did not significantly (p<0.05) influence dry matter yield of the plants (Table 1, 2). The effect of farmyard manure was insignificant (p<0.05) in dry matter accumulation in both seasons and locations as shown in Table 1 and 2. The effect of irrigation

Table 3: Interaction of nitrogen, farmyard manure and irrigation regime on days to 50% flowering of Switchgrass at lowland location in 2008/2009

	Farmyard manure (t ha^{-1})								
	0			5			10		
	Irrigation regime (days)			Irrigation regime (days)			Irrigation regime (days)		
Nitrogen (kg ha^{-1})	2	4	6	2	4	6	2	4	6
0	100.0	100.7^{c}	102.0	103.0	103.0	103.0	104.0	104.0	104.0
25	105.0	105.0^{b}	105.0	106.0	106.0	106.0	107.0	107.0	107.0
50	107.0	107.0^{a}	107.0	108.0	108.0	108.0	109.0	109.0	109.0
75	107.0	107.3^{a}	108.0	108.0	108.0	108.0	109.0	109.0	109.0
SE±		0.33							

Means in a column with different superscripts are significantly different (p<0.05) using DMRT at 5% level, SE: Standard error of means on dry matter accumulation was significant in both seasons and locations (Table 1, 2). At lowland, the least dry matter yield was obtained with the 6 day irrigation interval in both seasons. Two day interval irrigation had the highest dry matter yield as results indicated in both seasons. Increasing the irrigation intervals from 4 to 6 days did not significantly ($p<0.05$) differ in dry matter accumulation in both seasons (Table 1, 2). There was no significant ($p<0.05$) interaction effect between nitrogen, farmyard manure and irrigation regime on day to 50% flowering at both locations and seasons.

DISCUSSION

Nitrogen plays a vital role in the vegetative growth of plants. It encourages the development of early inflorescence and allows more flower and seed formation (Masters *et al*., 1993). This could have been the possible reason for the higher number of inflorescence per plant with nitrogen application. This is in agreement with the findings of Brejda (2000) and Masters *et al*. (1993). The highest number of inflorescence obtained with 2 days irrigation could be as a result of absence of water deficit thus maintaining continuous growth and development which is in line with the findings of Samson (2008) and Alexandrova *et al*. (1996). The response of seeds per plant to nitrogen rates could be attributed to the contribution made by nitrogen in the nutritional status of the soil which favoured plant growth and development. The nutrient deficient crop would produce less seeds out of which many will shrink and become infertile. This is probably the reason for obtaining higher seed number with increase in nitrogen rates. The increased number of seeds per plant as affected by manure application could be due to its contribution in to the nutritional status of the soil (Reeves, 1997). The highest number of seeds per plant recorded in 2 and 4 days irrigation intervals could be related to the availability and water use efficiently of the crop (Samson, 2008).

The application of 50 kg N ha^{-1} appeared to produce the best yield in both seasons, suggesting it to be the appropriate rate for seed production at Sokoto. The response of seed yield of switchgrass to nitrogen obtained is in conformity with the findings of John *et al*. (1998) who reported that switchgrass respond to moderate level of nitrogen fertilizer application. Seed yield of 320 kg ha^{-1} across all treatments and seasons was reported by Masters *et al*. (1993). Some commercial seed fields in Northeastern U.S.A. also reported seed yield average 224 kg ha^{-1} of pure live seed with 112 kg N ha^{-1}. Switchgrass yield of 390 kg ha^{-1} in Kansas (Sanderson *et al*., 2004) and 700 kg ha^{-1} in Missouri (John *et al*., 1998) were reported. Switchgrass yield, quality seed production can be improved with application of nitrogen (McLaughlin *et al*., 1999). Similarly, Brejda (2000) reported that nitrogen fertilizer increased seed yield of switchgrass. The increased seed yield of switchgrass as a result of nitrogen application may be attributed to an increased photosynthetic area exhibited as a result of good vegetative growth.

The increase in seed yield of switchgrass with increase in farmyard manure application conforms with the finding of Masters *et al*. (1993) who reported that seed yield of switchgrass are only obtained on soils which are well supplied with organic material and essential nutrients. The marginal difference in seed yield, due to the different rates of farmyard manure, exhibited in both the seasons suggests that switchgrass require a moderate level of farmyard manure application. Akoun (2005) also confirmed that manure increases the nutrient status of a soil, which leads to increase in yield. Seed yield differences between various irrigation regimes, seasons and across locations probably resulted from differences in irrigation intervals, which may have affected pollination and seed set.

The reason for the increase in time taken to attain 50% flowering with increase in nitrogen rate may be attributed to the important role nitrogen played in the vegetative growth (Thomson, 1996). This therefore, prolonged the flowering stages which conformed to the findings of Selim *et al*. (1993). The longer time taken by manure treatments to reach 50% flowering could be due to contributions made by manure to the fertility status of the soil. Manure is known to increase soil fertility which in turn prolongs vegetative growth period and maturity of crops (Reeves, 1997). The differences in the dry matter yield with varying irrigation days may be due to the fact that water stress reduces dry matter accumulation of vegetative component of switchgrass. Furthermore, the yield parameters of switchgrass in lowland areas were higher than that of the upland areas. It was also observed that lowland soils had higher concentration of electrical conductivity, organic carbon, total nitrogen, sodium, calcium, magnesium and cation exchange capacity than upland soils. The higher content of these moisture and minerals in the lowland soil compared to upland soils probably accounts for the higher yield performance of switchgrass in lowland areas.

CONCLUSION

The results of this study revealed that the combination of nitrogen at the rate of 50 kg ha^{-1}, 5 t ha^{-1} farmyard manure and 2 days irrigation intervals were the optimum conditions for switchgrass yield in Sokoto, Nigeria. Increasing the nitrogen, farmyard manure rates or irrigation intervals above these levels led only to a marginal increase in yield.

REFERENCES

Akoun, J., 2005. Effect of planting density and manure on the yield and yield components of the common onion (*Allium cepa* L.) Var. Nsukka Red. Nig. J. Horticultural Sci., 9: 43-48.

Alexandrova, K.S., P.D. Denchev and B.V. Conger, 1996. *In vitro* development of inflorescences from Switchgrass nodal segments. Crop. Sci., 36: 175-178.

Amans, E.B., M.K. Ahmed and J.Y. Yayock, 1990. Storage losses in onion bulbs as affected by plant spacing nitrogen fertilization and date of sowing. J. Hortic. Sic., 1: 1-7.

Bies, L., 2006. The biofuels explosion: Is green energy good for wildlife? Wildlife Soc. Bull., 34: 1203-1205.

Bransby, D., 2005. Switch grass profile. Bioenergy Feedstock Information Network (BFIN), OakRidge National Laboratory. pp: 40-47. https://bioenergy.ornl.gov/papers/misc/switchgrass-profile.html.

Brejda, J.J., 2000. Fertilization of Native Worm-Season Grasses. In: Native Warm Season Grasses: Research Trends and Issues anderson, B.E. and K.J. Moore (Eds.). CSSA, Madison, WI., pp: 177-2000.

Brice, J., L. Currah, A. Mahins and R. Bancrott, 1997. Onions Storage in the Tropics: A Practical Guide to Method of Storage and their Selection. National Research Institute, Chatha, UK., pp: 4-6.

Carpenter-Boggs, L., J.L. Pikull, M.F. Vigil and W.E. Riedell, 2000. Soil nitrogen mineralization influenced by crop rotation and nitrogen fertilization. Am. J. Soil Sci. Soc., 64: 2038-2045.

Casler, M.D., K.P. Vogel, C.M. Taliaferro and R.L. Wynia, 2004. Latitudinal adaptation of switchgrass populations. Crop. Sci., 44: 293-303.

Casler, M.D., K.P. Vogel, C.M. Taliaferro, N.J. Ehlke and J.D. Berdahl *et al*., 2007. Latitudinal and longitudinal adaptation of switchgrass populations. Crop Sci., 47: 2249-2260.

Entry, J.A., C.C. Mitchell and C.B. Backman, 1996. Influence of management practices on soil organic matter, microbial biomass and cotton yield in Alabama's Old Rotation. Biol. Fertility Soils, 23: 353-358.

Franzluebber, K., L.R. Hossner and A.S.R. Juo, 1998. Integrated Nutrient Management for Sustained Crop Production in Sub-Saharan Africa. Soil Management CRSP/TropSoils/Texas A and M University, USA., Pages: 50.

Hastings, C. and E.C. Prince, 2007. Local capacity and emerging opportunities for bioenergy production. Hastings stewardship council and Elorin, Eastern Lake Ontario Regional Innovation Network. pp: 6-7.

John J.B., L.E. Moser and K.P. Vogel, 1998. Evaluation of switchgrass rhizosphere microflora for enhancing seedling yield and nutrient uptake. Agron. J., 90: 753-758.

Kowal, J.M. and D.T. Knabe, 2002. An Agroclimatological Atlas of the Northern States of Nigeria. Ahmadu Bello University Press, Zaria, Nigeria, pp: 128.

Ladd, J.N., M. Amato, L. Zhou and J.E. Schultz, 1994. Differential effects of rotation, plant residue and nitrogen fertilizer on microbial biomass and organic matter in an Australian alfisol. Soil Biol. Biochem., 26: 821-831.

Masters, R.A., R.B. Mitchell, K.P. Vogel and S.S. Waller, 1993. Influence of improvement practices on big bluestem and indiangrass seed production in tallgrass prairies. J. Range Manage., 46: 183-188.

McLaughlin, S., J. Bouton, D. Bransby, B. Conger and W. Ocumpaugh *et al*., 1999. Developing Switchgrass as a Bioenergy Crop. In: Perspectives on New Crops and New Uses, Janick, J. (Ed.). ASHS Press, Alexandria, VA, USA, pp: 282-299.

REAP, 2004. Growing interest in grass biofuels: An ecological response to energy concerns Resource Efficient Agricultural Production, Canada, pp: 1-5

Reeves, D.W., 1997. The role of soil organic matter in maintaining soil quality in continuous cropping systems. Soil Tillage Res., 43: 131-167.

Samson, R., S. Mani, R. Boddey, S. Sokhansanj and D. Quesada *et al*., 2005. The potential of C_4 perennial grasses for developing a global BIOHEAT industry. Crit. Rev. Plant Sci., 25: 461-495.

Samson, R., 2007. Switchgrass productions in Ontario: A management guide. Resource efficient Agricultural production (REAP), Canada

Samson, R., 2008. Switchgrass: Living solar battery for the prairie.http://eap.mcgill.ca/MagRack/SF/Fall%2091%20L.htm

Sanderson, M.A, G. Brink, K. Higgins and D. Naugle, 2004. Alternative Uses of Warm-Season Forage Grasses. In: Warm-Season (c_4) Grasses. Moser, L.E. (Ed.). ASA and CSSA, Madison, WI., pp: 389-416.

Selim, S.M.A., M.R. Rokba, M.R. Hassan and M.A. Hussain, 1993. Effect of sowing dates, nitrogenous and potassium fertilization on roselle plant. Egypt J. Hortic., 20: 87-96.

Smolander, A., A. Kurka, V. Kitunen and E. Malkonen, 1994. Microbial biomass C and N and respiratory activity in soil of repeatedly limed and N-and P-fertilized Norway spruce stands. Soil Biol. Biochem., 26: 957-962.

Stegelmeier, B.L., S.A. Elmore, S.T. Lee, L.F. James and D.R. Gardner *et al*., 2007. Switchgrass (*Panicum virgatum*) Toxicity in Rodents, Sheep, Goats and Horses. In: Poisonous Plants: Global Research and Solutions, Panter, K. (Ed.). CABI Publishing, New York, USA., pp: 113-117.

Thomson, D.J., 1996. The seasons, global temperature and processions. Science, 268: 57-68.

Tian, G., G.O. Kolawole, B.T. Kong and G. Kirchoff, 2000. Nitrogen fertilizer replacement indexes of legume cover crop in the derived savanna of West Africa. Plant Soil, 224: 287-296.

USDA and NRCS, 2008. Plants profile for *Panicum virgatum* (Switchgrass). United State Department for Agriculture, Natural Resources Conservation Services, Washington, DC, USA., pp: 35-65.