Bang. J. Anim. Sci. 2010, 39(1&2) : 106 – 115 ISSN 0003-3588

EFFECT OF PHOSPHORUS FERTILIZER ON YIELD AND NUTRITIONAL VALUE OF SORGHUM (*Sorghum bicolor*) FODDER AT THREE CUTTINGS

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Abstract

An experiment was conducted to evaluate the effect of various levels of phosphorus fertilizer on the yield and nutritional value of sorghum fodder at three cuttings. The experiment was conducted by using 4 levels of Phosphorus fertilizer viz. 0 (T_0) 40 (T_1), 80 (T_2) and 120 (T_3) kg TSP/ha in a Completely Randomized Design (CRD). A significant effect ($P<0.01$) of phosphorus fertilizer application on plant height was observed with 80 kg TSP/ha at 60 days in 1st cutting and at 15 and 30 days in 2nd and 3rd cuttings. Highest green fodder was observed at 40 kg TSP/ha in 1st cutting but the effect was non significant. A significant effect ($P<0.01$) in green matter yield was observed at 80 kg TSP/ha in 2nd and 3rd cuttings. On the other hand, a significant effect ($P<0.01$) was observed on DM yield in first and second cuttings. Application of phosphorus fertilizer had a significant effect ($P<0.01$) on DM content in second cutting but non significant effect in 1st and 3rd cuttings with 80 kg TSP/ha. In 1st and 3rd cuttings, a significant difference on CP content was observed but in 2nd cutting the difference was non significant. CF, EE and P content were increased significantly in three cuttings. Highest phosphorus content was observed at 120 kg TSP/ha in each cutting. A significant effect ($P<0.01$) was observed on Ash content in 3rd cutting but the effect was non significant in 1st and 3rd cuttings. In 2nd cutting, IVOMD content of sorghum fodder was statistically significant but in 1st and 3rd cuttings the effect was non significant with 120 kg TSP/ha. A significant effect ($P<0.01$) was observed on ME content of fodder in 2nd and 3rd cuttings but the effect was non significant in 1st cutting at 120 kg TSP/ha. Based on the above findings, it may be suggested that sorghum fodder can be cultivated through the application of 80 kg TSP/ha and harvested at the age of 66 days at first cutting for maximum production.

Key words: Phosphorus, Sorghum fodder, Cuttings, Chemical composition, Metabolizable energy

Introduction

Feeding of green forage to livestock is essential for the maintenance of normal health and reproduction. In Bangladesh, about 90% of the ruminants diet consists of low quality roughage. Moreover, its availability is also far less than that of requirement (Jackson, 1980). As a result our cattle are left under-fed and maintained poorly. This problem is becoming

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(Received: December 06, 2010)

more acute because of steady rise in cattle population and diversion of more areas to grain crops for human consumption. Therefore, cultivation of quick growing good quality perennial forages like Napier, Para, German, Sorghum etc is urgently needed to mitigate the chronic shortage of fodders for feeding ruminants in Bangladesh. Phosphorus is one of the major essential plant nutrients after nitrogen and is the second most deficient plant nutrient (Munir *et al*., 2004). The optimum rate of phosphorus application is important in improving yields of most crops (Cisar *et al*., 1992). The yield and chemical composition of fodder varies due to many factors such as the soil quality, plant density, fertilizer dose, growing season and stage of maturity etc. Among the various factors, Phosphorus application is important which directly contributes to the quality and quantity of fodder production. Application of phosphorus fertilizer gradually increased plant height, stem diameter, number of leaves per plant, leaf area per plant and fodder yield (Khalid *et al*., 2003). Forage Sorghum (*Sorghum bicolor* L. Moench*)* is the best modern and high yielding fodder especially for making the hay and silage (Dogget, 1988 and Skerman and Riveros, 1999). Sorghum has a significant role in livestock production, particularly in the tropical zone where feedstuffs could not meet animal requirements due to many factors such as poor soil fertility, drought and others (Pholsen and Suksri, 2007) and hence it can be potential fodder crops in Bangladesh. Das *et al.*, (1996) observed that response of Sorghum to P was strongly influenced by soil P status as well as applied P level and was similar at three physiological stages of crop growth viz. boot leaf initiation, 50 percent flowering and maturity. In our country phosphorus fertilizer is normally used in the form of Triple Super Phosphate (TSP) and excessive use of this fertilizer may increase the cultivation cost. So the appropriate level of TSP application in Sorghum fodder cultivation is needed to know. Keeping this view in mind, the present research was planned to assess the yield and quality attributes of Sorghum fodder as influenced by different levels of TSP as a source of phosphorus fertilizer at three cuttings.

Materials and Methods

The experiment was carried out in the Shahjalal Animal Nutrition Field Laboratory of Bangladesh Agricultural University, Mymensingh during the period from April 2009 to September 2009. The texture of the soil was slity loam and neutral in nature. The experiment was conducted by using 4 levels of Phosphorus fertilizer viz. 0 (T_0), 40 (T_1), 80 (T_2) and 120 (T_3) kg TSP/ha in a Completely Randomized Design (CRD). Basal doses of urea and murate of potash (MP) were applied at the rate of 50 and 30 kg/ha respectively. During land preparation, the required amount of TSP (as per treatment), MP and one-half of the recommended amount of urea (25 kg/ha) were applied and rest one-half of the urea (25 kg/ha) was applied 5 weeks later as top dressing. Subsequently after 15 days after each cutting, the urea was applied at the rate of 50 kg/ha as top dressing. The seeds were sown by line sowing method at the rate of 50 kg/ha after completion of land preparation and fertilizer application. Plant height was measured every fortnightly. Green sorghum fodder in each plots were harvested on 66th day after sowing (1st cutting) and then 40th day after first and second cuttings, i.e. 2nd and 3rd cuttings respectively. During each cutting green biomass

yield was recorded in order to know the total green forage yield and representative samples of sorghum fodder was collected from each experimental plot. The samples were dried in the sun and ground through 40 mm mesh sieve and kept in polythene bags for further analysis. The nutrient contents of sorghum fodder in different cuttings were determined according to the methods of AOAC (2003). Phosphorus concentration of the samples was determined following the method of Page *et al*. (1982). The IVOMD and ME content of sorghum fodder was determined following the procedure of Menke *et al*. (1979) and the calculation was done according to Menke and Steingess (1988).

$$IVOMD = 16.49 + 0.9042\ GP + 0.0492\ CP + 0.0387\ TA$$
$$ME = 2.20 + 0.1357\ GP + 0.0057\ CP + 0.000286\ EE^2$$

Where,

IVOMD = *In vitro* organic matter digestibility (%)
ME = Metabolizable energy (MJ/ kg DM)
GP = Gas production (ml per 200 mg DM)
CP = Crude protein (g/kg DM)
TA = Total ash (g/kg DM)
EE = Ether extract (g/kg DM)

The data were analyzed using MSTAT statistical program for a Completely Randomized Design (CRD), and differences among the treatment means were determined by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results and Discussion

Plant height

Plant height of Sorghum fodder in different cuttings and different levels of P fertilizer application is shown in Table 1. It can be observed from the results that P fertilizer application had a significant effect ($P<0.01$) on plant height at 60 days in first cutting but the effect was statistically non significant at 15, 30 and 45 days in first cutting. In first cutting, the tallest plant was (160.0 cm) found with the application of 80 kg TSP/ha and the shortest plant (132.41 cm) at control group (without P). The plant height was gradually increased with increasing level of phosphorus up to 80 kg TSP/ha and the plant height was not increased with further application of phosphorus fertilizer. Similar responses were obtained by Dwivedi *et al*. (1997) who observed that the crop growth rate, net assimilation rate and leaf weight ratio were attained maximum at 80 kg P_2O_5/ha. On the other hand, Bothe *et al*., (2000) reported that the tallest plant was found at 75 kg P_2O_5/ha over a range of P level from 0-75 kg P_2O_5/ha. Similarly, Sairam *et al*., (1984) reported that the plant height was increased with the increasing P application. A significant effect of P application in plant height was observed in 2nd and 3rd cutting (Table 1).

Table 1. Effect of application of different doses of P fertilizer to Sorghum fodder on plant height (cm) green forage and DM yield in 1st, 2nd and 3rd cuttings

Parameters	Treatments[#]				SED	Level of Sig.
	T_0	T_1	T_2	T_3		
First cutting						
Plant height (cm)						
15 DAS	25.81	26.57	29.40	26.93	0.63	NS
30 DAS	41.10	44.17	48.26	46.99	1.20	NS
45 DAS	81.21	84.67	88.16	84.12	1.08	NS
60 DAS	132.41^{d}	147.48^{a}	160.00^{b}	138.58^{c}	3.33	**
Yield (MT/ha)						
Green forage	23.75	26.16	25.58	22.49	0.79	NS
DM	3.59^{b}	4.14^{a}	4.0^{a}	3.40^{b}	0.08	**
Second cutting						
Plant height(cm)						
15 DAS	33.70^{c}	36.93^{b}	39.05^{a}	32.47^{c}	0.89	**
30 DAS	49.35^{d}	64.57^{c}	67.13^{a}	56.00^{c}	2.28	**
Yield (MT/ha)						
Green forage	2.66^{c}	4.37^{ab}	6.08^{a}	4.05^{b}	0.40	**
DM	0.38^{c}	0.63^{b}	0.89^{a}	0.59^{b}	0.02	**
Third cutting						
Plant height(cm)						
15 DAS	47.60	49.20	54.11	45.57	1.28	NS
30 DAS	51.40^{c}	71.20^{ab}	72.60^{a}	60.13^{b}	2.77	**
Yield (MT/ha)						
Green forage	1.34^{c}	1.15^{d}	1.58^{a}	1.40^{b}	0.05	**
DM	0.17	0.15	0.21	0.18	0.02	NS

[#] T_0 = 0 kg TSP/ha (without P), T_1 = 40 kg TSP /ha, T_2 = 80 kg TSP/ha and T_3 = 120 kg TSP/ha; NS = P>0.05, ** = P<0.01

SED = Standard error deviation; DAS = Days after sowing

[a,b,c,d] Mean values with different superscripts differ significantly

Yield

It can be seen from the Table 1 that the green production biomass of sorghum was the highest (26.16 MT/ha) and (25.58 MT/ha) at the level of 40 and 80 kg TSP/ha as compared to the level of 0 kg TSP/ha (23.75 MT/ha). These results are statistically non significant (P>0.05). It can be observed from the result that P fertilizer application had significant effect on yield of total green forage and influenced by increasing level of phosphorus fertilizer in

both second and third cuttings. In second cutting, green matter yield was highest (6.08 MT/ha) at the level of 80 kg (T_2) TSP/ha while the lowest yield (2.66 MT/ha) was in T_0 (control). Similarly in third cutting, the highest yield was found in T_2 (80 kg TSP/ha) and the lowest (1.15 MT/ha) in T_1 (40 kg TSP/ha). Similar results were found by Sairam *et al*., (1984). They reported that dry weight, leaf area per plant and nitrogen uptake were increased with phosphorus application and inoculation with Rhizobium culture. Other studies have also indicated the positive correlation between green fodder yield of pangola grass and P fertilizer (Bhardwaj *et al*., 1995). Khot *et al*. (1997) reported that the green forage yield increased significantly with increasing levels of P fertilizer. Abdullah *et al*. (2000) also reported that total yield of green forage increased with the increasing level of P fertilizer. The result of present findings can also be supported by the earlier observation in German grass (Malak, 2005) and in Napier grass (Islam, 2007).

It is revealed from the Table 1 that the highest DM yield was found (4.14 MT/ha) with the application of 40 kg TSP/ha (T_1) while the other levels were 4.0, 3.59 and 3.40 MT/ha with the application 80 (T_2), 0 (T_0) and 120 (T_3) kg TSP/ha in first cutting. In the first and second cuttings, a significant ($P<0.01$) effect on DM yield among the treatments was observed. But no significant ($P>0.05$) effect on DM yield among the treatments was observed in third cutting. Previous works also indicated that the application of P fertilizer increase in the DM yield of oat fodder (Mohiuddin, 2002). Similar results were also obtained by Bhagwan *et al*. (1997) who indicated that DM yield increased with the increasing level of P rated up to 60 kg P/ha.

Chemical composition

It can be seen from the Table 2 the highest DM content (15.82 g/100g) was found from the application of 40 kg TSP/ha followed by 15.63, 15.11 and 15.07 g/100g with the application of 80, 0 and 120 kg TSP/ha, respectively in first cutting. However, no significant ($P>0.05$) effect of P fertilizer on DM content was observed in first and third cutting. The findings of the present experiment were in keeping with the results of previous works of Khaleduzzaman *et al*. (2007). They reported that DM content had not increased significantly with the increasing levels of phosphorus fertilizer application. Similar results were also observed by Mohiuddin (2002) on oat fodder. In second cutting, there was a significant ($P<0.01$) difference of DM content was observed.

As is observed from the Table 2 that there was a significant ($P<0.01$) difference on CP content in first and third cutting. The results are in contrast with the findings of Keshwa and Jat, (1992) who reported that CP content of summer pearl millet increased significantly with the increasing level of P fertilizer application. Similar results also found by Polat *et al*., (2007) who reported that crude protein concentrations were significantly enhanced with increasing P fertilizer amounts. However in second cutting, the effect of P fertilizer on CP content was not significant ($P>0.05$). In first, second and third cutting the effect of P fertilizer on CF content was statistically significant ($P<0.01$). Previous works also indicated a significant ($P<0.01$) effect on crude fiber content of fodder cuttings with application of 80 kg P/ha (Virender *et al*., 2001). The results are contrasted with the findings of El-Houssini *et al*.,

(2005) who reported that CF content was significantly decreased from 16.01 to 14.55% with the increasing phosphorus application rates.

Table 2. Chemical composition of sorghum fodder at different levels of P fertilizer in 1st, 2nd and 3rd cuttings

Parameters	Treatments[#]				SED	Level of Sig.
	T_0	T_1	T_2	T_3		
First cutting						
DM (g/100g fresh sample)	15.11	15.84	15.63	15.07	0.40	NS
Chemical composition (g/100 g DM)						
CP	6.61^{d}	6.89^{b}	6.81^{c}	6.94^{a}	0.04	**
CF	37.05^{a}	36.67^{ab}	36.37^{b}	36.07^{bc}	0.13	**
EE	3.38^{bc}	3.41^{b}	3.44^{ab}	3.51^{a}	0.02	*
Ash	10.32	9.84	9.94	10.12	0.13	NS
NFE	42.64^{d}	43.19^{c}	43.44^{a}	43.36^{b}	0.09	**
P	0.14^{d}	0.17^{c}	0.20^{b}	0.24^{a}	0.01	**
Second cutting						
DM (g/100g fresh sample)	14.21^{d}	14.32^{c}	14.66^{a}	14.51^{b}	0.052	**
Chemical composition (g/100 g DM)						
CP	6.69	6.94	6.85	6.97	0.05	NS
CF	34.51^{b}	34.77^{b}	35.06^{ab}	35.56^{a}	0.13	**
EE	3.27^{d}	3.31^{c}	3.37^{b}	3.44^{a}	0.02	**
Ash	9.24	9.51	9.48	9.43	0.09	NS
NFE	46.29^{a}	45.47^{b}	45.24^{bc}	44.60^{c}	0.22	**
P	0.12^{d}	0.16^{c}	0.19^{b}	0.21^{a}	0.01	**
Third cutting						
DM (g/100g fresh sample)	12.94	13.06	13.07	13.01	0.021	NS
Chemical composition (g/100 g DM)						
CP	6.70^{c}	7.05^{a}	6.78^{bc}	6.82^{b}	0.05	**
CF	32.49^{d}	33.08^{b}	33.70^{c}	34.03^{a}	0.18	**
EE	3.01^{d}	3.13^{c}	3.17^{b}	3.26^{a}	0.03	**
Ash	8.93^{b}	9.18^{a}	8.31^{d}	8.34^{c}	0.16	*
NFE	48.87^{a}	47.56^{c}	48.04^{b}	47.55^{c}	0.33	**
P	0.11^{d}	0.15^{c}	0.17^{b}	0.20^{a}	0.01	**

[#] T_0 = 0 kg TSP/ha (without P); T_1 = 40 kg TSP /ha; T_2 = 80 kg TSP/ha; T_3 = 120 kg TSP/ha; NS = P>0.05, * = P<0.05, ** = P<0.01

SED = Standard error deviation

[a,b,c,d] Mean values with different superscripts differ significantly

In all cuttings, there was a significant (P<0.01) difference in EE content of Sorghum fodder. Similar results were found by Virender *et al*., (2001) who reported that EE content of berseem fodder increased significantly (P<0.01) with application of 80 kg P/ha. Similar results were also found by Islam (2007). The effects of P fertilization on ash content was statistically non significant (P>0.05) but in third cutting the effect was statistically significant (P<0.05). Similar responses were also found by Uddin *et al*. (2005a) in oat fodder who reported that ash content decreased significantly (P<0.01) with the increasing levels of P fertilization. Previous works of Malak (2005) also indicated that different levels of P fertilizer has a non significant (P>0.05) effect on ash content of German grass. Phosphorus fertilization had a significant (P<0.01) positive effect on P concentration of Sorghum fodder. It can be seen that the phosphorus content of Sorghum fodder is 0.14, 0.17, 0.20 and 0.24 % in first cutting and 0.12, 0.16, 0.19 and 0.21% in second cutting and 0.11, 0.15, 0.17 and 0.20% in third cutting, respectively (Table 2). It is revealed from the results that highest P content (0.24% in first cutting, 0.21% in second cutting and 0.20% in third cutting) was found due to application of 120 kg TSP/ha and lowest at control (0 kg TSP/ha) in every cutting which is significantly lower than the 120 kg TSP/ha. These results are in agreement with the work conducted by Awan and Abbasi (2000) who found that with increasing levels of P fertilizer phosphorus uptake increased. Similar responses were also found by Hirpara *et al*. (1992) who reported that P uptake of Sorghum fodder increased with increasing levels of P fertilizer. David *et al*. (1997) reported that the mean values of P content for *Andropogon gayanus* Kunth increased from 0.09 to 0.12% as the increasing levels of P application from 0 to 75 kg P_2O_5/ha. Similar results were also found by Cecato *et al*. (2004) who reported that P content showed an increase by increasing levels of phosphorus (P<0.05).

In vitro digestibility and energy contents

In vitro organic matter digestibility (IVOMD) and metabolizable energy (ME) contents of Sorghum fodder as affected by different levels of P fertilizers at 1st, 2nd and 3rd cuttings are shown in Table 3. The highest value for IVOMD (57.27%) was found at 120 kg TSP/ha and the lowest value (53.92%) at 0 kg TSP/ha in first cutting. It is apparent that the effect of P fertilizer on IVOMD content of Sorghum fodder was not significant (P>0.05) at first and third cutting but in second cutting the IVOMD was statistically significant (P<0.01). The results are in agreement with the findings of Chowdhury (1998) who indicated that application of 60 kg P_2O_5/ha had significant effect on IVOMD as compared to control (0 kg P_2O_5/ha). Similar response was found by Pervin (2004) who reported that the highest value for IVOMD (62.42%) at 116.5 kg P_2O_5/ha and the lowest value (60.09%) at 0 kg P_2O_5/ha. It is revealed from the Table 3 that the ME content of Sorghum fodder increased with increasing levels of P fertilizer in first cutting. The highest value of ME (7.96 MJ/kg DM) was found at 120 kg TSP/ha and lowest value (7.60 MJ/kg DM) at 0 kg TSP/ha in first cutting. But in first cutting the results are statistically non significant (P>0.05). On the other hand, the treatments were statistically significant (P<0.01) in second and third cutting.

From the results it can be concluded that sorghum fodder can be harvested at 66 days of age in first cutting with 80 kg TSP/ha for optimum production.

Table 3. *In vitro* organic matter digestibility (%) and metabolizable energy (ME/kg DM) contents of Sorghum fodder at different levels of P fertilizer in 1st, 2nd and 3rd cuttings

Parameters	Treatments#				SED	Level of Sig.
	T_0	T_1	T_2	T_3		
First cutting						
IVOMD (%)	53.92	55.11	56.53	57.27	0.65	NS
ME (MJ/kg DM)	7.60	7.81	7.86	7.96	0.08	NS
Second cutting						
IVOMD (%)	52.90^{c}	53.90^{b}	54.86^{ab}	55.35^{a}	0.32	**
ME (MJ/kg DM)	7.32^{d}	7.47^{c}	7.61^{b}	7.68^{a}	0.05	**
Third cutting						
IVOMD (%)	52.78	52.75	51.71	52.62	0.39	NS
ME (MJ/kg DM)	7.08^{c}	7.25^{b}	7.38^{ab}	7.42^{a}	0.05	**

T_0 = 0 kg TSP/ha (without P); T_1 = 40 kg TSP/ha; T_2 = 80 kg TSP/ha; T_3 = 120 kg TSP/ha; NS = P>0.05, * = P<0.05, ** = P<0.01

SED = Standard error deviation

^{a,b,c,d} Mean values with different superscripts differ significantly

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