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Research Paper

Effect of agronomic management on oxalate and silica content in pearl millet (*Pennisetum glaucum*) × napier (*Pennisetum purpureum*) hybrid

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ABSTRACT

A field experiment was conducted at Rahuri, during 2009–10 to 2010–11 to study the effect of planting material, cutting management and fertilizer levels on growth, yield and quality of *bajra* or pearl millet [*Pennisetum glaucum* (*L.*) R. Br.] × napier grass (*Pennisetum purpureum* Schum) hybrid. The oxalic acid content in B×N hybrid was not influenced significantly due to different planting material, whereas silica content showed the inconsistent trend. Crop cut at an interval of 45 days registered significantly higher oxalic acid (2.05%) content over cut at 60 and 75 days interval, while significantly lowest silica (2.43%) was observed at 45 days cutting interval on pooled mean basis. Increase in fertilizer levels increased oxalic acid content, whereas decreased the silica content progressively. Application of 150% of recommended dose of fertilizer recorded the maximum oxalic acid (2.01%), while the minimum of silica content (2.23%).

Key words **:** *Bajra* or Pearlmillet × Napier hybrid, Cutting interval, Fertilizer levels, Oxalic accumulation, Planting material, Silica content

Bajra × Napier hybrid is an inter - specific hybrid (2n=3x=21) between *bajra* or pearl millet (*Pennisetum glaucum)* and napier grass (*Pennisetum purpureum*). Oxalate and silica are common constituent of plants and play various roles in plants, viz. Ca regulation, ion balance, plant protection, tissue support and heavy metal detoxification (Libert and Franceschi, 1987). However, when oxalate is in the form of calcium oxalate, calcium is less available for absorption (Mc Conn and Nakata, 2004), which ultimately reduces milk yield and causes calcium deficiency in animals. Tal Kipnis and Levena Dabush (2006) and Kipnis and Dabush (2006) reported that *Bajra* × Napier hybrid possesses high concentrations of total as well as soluble oxalates. Many crop plants accumulate oxalate in the range of 3–8% (w/w) of their dry weight (Massey, 2003)

Although oxalate and silica content in Bajra × Napier (B×N) hybrid adversely affects nutritional quality as animal feed, studies on oxalate and silica in B×N hybrid have received little attention. Concerted research is required to understand how agronomic practices could minimize their accumulation in plants. Tokarnia *et al.* (2002) reported that oxalate concentration in B×N hybrid plants is sufficient to induce feed poisoning in animal in sole feeding. Keeping in view the above fact, an experiment was conducted to investigate the effect of agronomic management on calcium oxalate and silica content in B×N hybrid.

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MATERIALS AND METHODS

The field experiment was conducted on *Vertic haplustept* during 2009–10 and 2010–11 at Mahatma Phule Krishi Vidyapith Rahuri, Maharashtra. The soil was clayey in texture. The chemical analysis indicated that the soil was low in available nitrogen (198.0 kg/ha), medium in available phosphorus (17.4 kg P_2O_5/ha) and high in available potassium (515.0 kgK_2O/ha). It was moderately alkaline in reaction (pH 8.02) with 0.24 dS/m electrical conductivity. The organic carbon content was 0.41%.

The field experiment was laid out in split-plot design. The treatment consisted of 9 main plot of combinations including 3 planting material [P_1 rooted slip two/hill (90 cm × 60 cm); P_2 one eye bud sets one/hill (90 cm × 30 cm); P_3 two eye bud sets one/hill (90 cm × 60 cm)], 3 cutting management [C_1 45 days cutting interval (7 cuttings/ year); C_2 60 days cutting interval (6 cuttings/year); C_3 75 days cutting interval (5 cuttings/year)] and 3 fertilizer levels [F_1 100% RDF (150:60:60 kg N, P_2O_5, K_2O/ ha); F_2 125% RDF (187.5:75:75 kg N, P_2O_5, K_2O/ha); F_3 150% RDF (225:90:90 kg N, P_2O_5, K_2O/ha)] as subplot treat-

ments. The planting of B×N hybrid was undertaken on 7 July 2009 and gap filling was carried out on 31 July 2009 in order to maintain the desired plant population. The same plant population was maintained during subsequent year of experimentation. Two rooted slips and two-eye bud sets were planted per hill at the distance of 90 cm × 60 cm apart from row to row and plant to plant. In all 37,037 rooted slips and 18,518 two-eye bud sets were planted over 1 ha area. Whereas the one-eye bud sets/hill were planted at a distance of 90 cm × 30 cm apart. The total number of one-eye bud sets required for 1 ha area was 37,037. Two pre-emergence irrigations were given for uniform establishment of rooted slips and for spouting of one-eye bud and two-eye bud sets. Besides, 11 irrigations were applied during both the years. There was no any pest and disease incidence was observed during entire period of investigation. The standard analytical methods for plant analysis were used for estimation of oxalic acid by Abaza *et al*. (1968) and silica by Van Soest (1975).

RESULTS AND DISCUSSION

Quality parameters

Planting material: The oxalic acid content in B×N hybrid was not influenced significantly due to different planting material during both the years and on pooled mean (Table 1). The silica content showed the inconsistent trend during the experimentation. Among the planting material, two-eye bud sets recorded significantly the lowest silica content in B×N hybrid than rooted slips and one-eye bud sets during the first year and pooled mean, while during the second year the silica content remains unaffected due to different planting material and it was non-significant during the second year. The crude protein and crude fibre content were not significantly influenced due to planting material.

Cutting management: The higher level of oxalate content in forages adversely affects the nutritional quality of animal feed. The oxalic acid content in B×N hybrid was significantly lowest during both the years and on pooled mean at 75 days cutting interval than 45 days and 60 days cutting intervals (Table 1). An increase in the cutting interval decreased the oxalic acid content in B×N hybrid, while decrease in the cutting interval increased the oxalic acid content; this might be due to prolonged interval the oxalic acid content changed into carbonate or bicarbonate as result there was reduction in oxalic acid content. The results confirm the findings of Tal Kipnis and Levana Dabush (2006), Rahman *et al*. (2009) and Rahman and Kawamura (2011). The silica content in B×N hybrid was significantly lowest at 45 days cutting interval (2.45, 2.41 and 2.43%, respectively) during both the years and on pooled mean as compared to 60 days and 75 days cutting intervals. The increase in cutting interval increased the silica content in B×N hybrid. There was a linear response of silica content with increasing time of cutting interval and maximum silica content was observed, where crop was cut at an in-

Table 1. Oxalic acid, silica, crude protein and crude fibre content in Bajra × Napier hybrid as influenced by different treatment (Pooled mean of 2 seasons)

Treatment	Oxalic acid content (%)	Silica content (%)	Crude protein content (%)	Crude fibre content (%)
Planting material				
P_1 Rooted slips (90 cm × 60 cm)	1.98	2.58	6.63	31.4
P_2 One-eye bud sets (90 cm × 30 cm)	1.97	2.57	6.61	31.5
P_3 Two-eye bud sets (90 cm × 60 cm)	1.97	2.55	6.59	31.5
SEm±	0.003	0.015	0.00	0.14
CD (P=0.05)	NS	0.048	NS	NS
Cutting management				
C_1 45 days interval	2.05	2.43	6.75	30.2
C_2 60 days interval	1.99	2.56	6.58	31.5
C_3 75 days interval	1.87	2.71	6.50	32.6
SEm±	0.003	0.015	0.00	0.14
CD (P=0.05)	0.009	0.048	0.01	0.44
Fertilizer levels				
F_1 100% RDF	1.94	2.90	6.38	33.7
F_2 125% RDF	1.97	2.58	6.61	31.6
F_3 150% RDF	2.01	2.23	6.84	29.0
SEm±	0.001	0.008	0.00	0.24
CD (P=0.05)	0.003	0.024	0.01	0.70

RDF: Recommended dose of fertilizer

terval of 75 days because of more time for absorption of silica in plant. Similar result was also reported by Reddy and Reddy (2012). Increase in cutting interval decreases the crude protein content but increased the crude fibre content. Similar results were also reported by Bora *et al*. (2011) and Reddy and Reddy (2012).

Fertilizer levels: An application of 100% of RDF to B×N hybrid recorded significantly minimum oxalic acid content compared with than 125% and 150% of RDF. The oxalic acid content in B×N hybrid was increased with the increase in recommended dose of fertilizer (RDF), because of higher dose of fertilizers resulted more vegetative growth and development and increases in metabolic activities. The higher metabolic activity could increase the oxalic acid content in B×N hybrid. The similar result was also reported by Govindaswami and Manickam (1988). An application of 150% of RDF to B×N hybrid recorded significantly lowest silica content as compared to 100% and 125% of RDF.

The application of 150% RDF to B×N hybrid recorded significantly higher average crude protein content (6.84%) and minimum crude fibre content (29.02%) than rest of the fertilizer levels on pooled mean. This might be due to higher nitrogen supply, more rapidly the synthesized carbohydrates were converted to protein and protoplasm and smaller proportion was left available for cell wall material, thus carbohydrate and nitrogen provides skeleton for protein synthesis (Bora *et al*. 2011). The crude fibre content decreased with increase in RDF because higher dose of fertilizer application to B×N hybrid delayed the maturity particularly by nitrogen, whereas lower dose of fertilizer application to the B×N hybrid leads to forced maturity within a short span of time. This might be governed the phenomenon of fibre synthesis. Bora *et al.* (2011) also reported the similar trend.

Interactions: The interaction effects between cutting management and fertilizer levels were found significant for oxalic acid content on pooled mean basis. Application of 100% RDF to B×N hybrid along with cutting at every 75 days interval registered significantly lowest oxalic acid content (Table 2). Decline in cutting interval (45 days) along with higher dose of fertilizer recorded significantly higher oxalic acid content. The interaction between cutting management and fertilizer levels was significant for silica content of B×N hybrid on pooled mean basis. The cutting interval decides the maturity period of B×N hybrid, longer the cutting interval higher will be the silica content (Table 3). If it was combined with fertilizer levels then the higher levels of fertilizer application diluting the mineral matter by producing higher biomass. Hence, combinely both the factors affect the silica content in B×N hybrid. These results confirm the findings of Pathan and Bhilare (2008) and Reddy and Reddy (2012).

Use lower level of fertilizer application (100% RDF) and cutting at 45 days interval reduced the oxalate content in B×N hybrid to acceptable levels. The quality parameters of green forage the silica were found improved by cutting of B×N hybrid at every 45 days interval than 60 and 75 days cutting interval.

Growth yield parameters

Planting material: Planting material of rooted slips re-

Table 2. Interaction effects of cutting management fertilizer levels on oxalic acid content (%) of Bajra × Napier hybrid (Pooled mean of 2 seasons)

Treatment	F_1–100% RDF	F_2–125% RDF	F_3–150% RDF
C_1 45 days interval	2.03	2.05	2.08
C_2 60 days interval	1.95	1.99	2.04
C_3 75 days interval	1.83	1.87	1.91
CF		SEm±	CD (P=0.05)
F means at same levels of C means		0.002	0.007
C means at same levels of F means		0.003	0.007

Table 3. Interaction effects of cutting management x fertilizer levels on silica content (%) of Bajra×Napier hybrid (Pooled mean of 2 seasons).

Treatment	F_1–100% RDF	F_2–125% RDF	F_3–150% RDF
C_1 45 days interval	2.74	2.45	2.09
C_2 60 days interval	2.88	2.58	2.22
C_3 75 days interval	3.06	2.70	2.36
CF		SEm±	CD (P=0.05)
F means at same levels of C means		0.01	0.04
C means at same levels of F means		0.01	0.04

corded significantly maximum plant height, tillers/plant, total green forage yield and total dry matter yield as compared to one-and two-eye bud sets on pooled mean (Table 4). This might be due to the already established root-system in rooted slips which starts function early to absorb moisture and nutrients from soil immediately after planting, increases cell turgidity, cell multiplication and cell elongation resulted in increase in plant height compared to one- and two-eye bud sets as these sets required certain period for establishment of roots. The maximum number of tillers with rooted slips might be due to initial status of reserve carbohydrates in rooted slips would be helpful to better establishment of root-and shoot-system of the plants that promotes proper outcome of auxiliary buds present in the rooted slips which turns on maximum number of tillers/bunch as compared to one-and two-eye buded sets used for planting purpose. The highest green forage yield in rooted slips might be associated with the early crop establishment, better root-system development which helps in efficient absorption of nutrients and moisture from the soil which induced the profused vegetative growth.

Cutting management: The average plant height (201.70 cm) and number of tillers/bunch of B N hybrid was significantly higher at 75 days cutting interval than 45 and 60 days cutting intervals. This might be due to sufficient time was available for apical growth of stem, resulting in more height at 75 days cutting interval. Plant height increased with increasing cutting intervals which might be also due to advance increased in apical growth of stem till flowering. A delay in harvesting time, probably gives sufficient time for continued growth and development resulting in maximum plant height recorded at 75 days cutting interval. Increase in cutting interval significantly increased the number of tillers/bunch with recurrent cutting this might be due to maximum meristematic activity and efficient translocation of photosynthates to the growing apex (Tessema and Alemayehu, 2010).

The total green forage and dry matter yield increased at an interval of 60 days providing sufficient time for assimilation of organic constituents, formed during process of photosynthesis. This photosynthets were utilized by plants for vegetative growth and developments which in turn more number of leaves and tillers resulted higher green forage yield. Considerable variation in herbage yield (green and dry) with extended cutting interval might be attributed to the improvement in yield attributes such as more plant height, number of leaves/bunch, number of tillers/bunch, leaf stem ratio and dry-matter accumulation. Ram *et al*. (2007) also reported increase in dry-matter yield of grasses with increase in cutting interval.

Fertilizer levels: Application of 150% of RDF to B×N hybrid recorded significantly maximum plant height, number of tillers/plant, total green forage and dry matter yield as compared to 100% and 125% RDF on pooled mean

Table 4. Plant height, number of tillers /plant, total green forage and dry-matter yield in Bajra × Napier hybrid as influenced by planting material, cutting management and fertilizer levels (pooled mean of 2 seasons)

Treatment	Plant height (cm)	Number of tillers/ plant	Total green forage yield (t/ha)	Total dry matter yield (t/ha)
Planting material				
P_1 Rooted slips (90 cm × 60 cm)	182.2	54.6	267.6	53.0
P_2 One eye bud sets (90 cm × 30 cm)	176.4	31.3	257.1	49.9
P_3 Two eye bud sets (90 cm × 60 cm)	173.2	52.7	245.5	47.1
SEm±	0.60	1.58	2.27	0.50
CD (P=0.05)	1.80	5.15	7.40	1.63
Cutting management				
C_1 45 days interval	150.1	40.8	248.2	44.8
C_2 60 days interval	179.9	45.8	268.3	53.3
C_3 75 days interval	201.7	52.1	253.9	52.0
SEm±	0.60	1.58	2.27	0.50
CD (P=0.05)	1.80	5.15	7.40	1.63
Fertilizer levels				
F_1 100% RDF	158.3	44.1	243.0	44.6
F_2 125% RDF	177.4	46.3	258.6	50.3
F_3 150% RDF	196.1	48.4	268.7	55.0
SEm±	0.30	0.10	0.66	0.15
CD (P=0.05)	0.90	0.30	1.97	0.44

RDF: recommended dose of fertilizer

Table 5. Economics of Bajra × Napier hybrid as influenced by agronomic management on (pooled mean of 2 seasons).

Treatment	Gross returns (×10³ ₹/ha)	Cost of cultivation (×10³ ₹/ha)	Net returns (×10³ ₹/ha)	Benefit: cost ratio
Planting materials (main-plot)				
P_1 Rooted slips	147.2	75.4	71.8	2.3
P_2 One eye bud sets	141.5	64.3	77.2	2.4
P_3 Two eye bud sets	135.1	64.3	70.8	2.3
Cutting management				
C_1 45 days interval	136.5	70.7	65.8	2.2
C_2 60 days interval	147.6	68.1	79.5	2.5
C_3 75 days interval	139.6	65.2	74.4	2.5
Fertilizer levels (sub-plot)				
F_1 100% RDF	133.7	67.0	66.7	2.3
F_2 125% RDF	142.3	68.1	74.2	2.4
F_3 150% RDF	147.8	68.8	78.9	2.4

basis. The beneficial effect of application of increased RDF associated with higher photosynthetic activity and protein synthesis, which promotes cell division and elongation that in turn accelerates the vegetative growth. The overall effect of all nutrients on yield parameters was positive which resulted in higher green forage yield. Increase in RDF significantly increases the dry matter yield of B×N hybrid (Pathan and Bhilare, 2008).

Economics

Economics of cultivation of B×N hybrid revealed the profitability of different treatment combinations of planting material, cutting management and fertilizer levels (Table 5).

Planting of B×N hybrid with one-eye bud sets fetched the maximum net monetary returns and showed the highest benefit: cost ratio. However, two-eye buded sets registered the lowest net returns and benefit: cost ratio. Cutting at 60 days interval resulted in maximum net monetary returns and benefit: cost ratio, which was followed by 75 days cutting interval. Among the fertilizer levels, application of 150% RDF to B×N hybrid provided the highest net monetary returns and benefit: cost ratio.

It was concluded that oxalic acid content in B×N hybrid was not significantly influenced by different planting materials, whereas silica content showed inconsistent trend. Crop cut at an interval of 75 days cutting interval showed the lowest oxalic acid content with the highest silica content. Increasing the RDF increased the oxalic acid content and decreased the silica content.

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