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Baby corn production and utilization of remaining fodder in total mixed ration of buffalo calves

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ABSTRACT

This study was taken up to find out suitable maize variety cultivated with or without fertilizer for baby corn ear production and evaluation of leftover fodder/green stalks as livestock feed. Experiment-1: Six varieties of hybrid maize [PMH-1 grain (V_1), Bulland (V_2), African Tall (V_4), Dekalb 7074 Monsanto (V_5), Proagro 4640 (V_6), Egyptian variety G-5414 (V_7)] and one composite maize variety J1006 (V_3) were cultivated without fertilizer (F_1), with either *Azotobacter* treated seed (F_2), recommended dose of fertilizer (F_3), or $F_2 + F_3$ (F_4) at the University Farm. Experiment-2: The leftover fodder of the best baby corn hybrid variety and that from V_3 were evaluated in total mixed ration (TMR) as feed for buffalo calves. In *Experiment-1* the weight of edible cob without husk and fodder yield were the highest ($P<0.01$) in V_2. The *in vitro* net gas production, digestibility of nutrients and ME availability from the fodder was the highest in V_7 comparable to V_2, but higher than other varieties. The fodder from baby corn G-5414 was considered as the best. In *Experiment-2* the chemical composition and *in vitro* evaluation of TMRs containing either conventional maize fodder (TMR-1; J-1006) or baby corn fodder (TMR-2; Baby corn G-5414) were comparable. Both the TMRs were iso-nitrogenous and iso-caloric. The digestibility of proximate and a cell wall constituent was considerably higher in calves fed TMR-2 than those fed TMR-1. The efficiency of nitrogen utilization, blood profile and excretion of purine derivatives in the urine were comparable in both groups. It was concluded that fresh baby corn fodder can be utilized efficiently by the ruminants without any adverse effect on the health of animals.

Keywords: Baby corn production, Buffalo calves, *In vitro,* Leftover green fodder, Utilization

The shortage of feedstuffs in India have been reported from time to time (Bakshi and Wadhwa 2004, Ravi Kiran *et al.* 2012). The Planning Commission's Working Group on Animal Husbandry and Dairying's reported a deficit of 64.21 and 24.83% in demand and supply in 2020 (Rathod and Dixit 2019). Therefore, in order to bridge this gap, newer alternate fodder resources need to be explored.

Different genotypes of maize, viz. baby corn, green cob and pop corn, seed varieties besides fodder varieties are gaining immense popularity. Baby corn and green cobs are in high demand. Baby corn is ear of maize (*Zea mays* L.) plant harvested young, before fertilization. After 50–55 days of sowing, three to five baby corn ears are hand-picked from each plant as soon as 2–5 cm silk emerges from the ear tips. In India, the average baby corn production is about 7.5–8.5 tonnes/ha. Out of this the human-edible husked baby corn cob is only 15%, while the remaining 85% constitutes of outer peel/husk with a silky thread-like structure called baby corn husk with silk. It contains 11–12% CP and can be fed fresh or after ensiling and is readily acceptable, palatable, relished by the animals and has nutritive value comparable to conventional maize fodder (Bakshi and Wadhwa 2012, Bakshi *et al.* 2016, Anonymous 2017). Another by-product is green stalks with leaves, also called leftover baby corn fodder. Keeping in view the harmful effects of chemical fertilizers on the environmental health and escalation in the cost of crop production, these should be used judiciously. Integrated nutrient management (INM) is effective tool for judicious application of fertilizers. The adoption of INM practices will increase the supply and availability of soil nutrients to the crop, reduce the production cost and will boost the economic status of the farmers. This study was taken up to find out suitable maize variety cultivated with or without fertilizer for baby corn ear production and evaluation of leftover fodder/green stalks in the total mixed ration (TMR) of buffalo calves.

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MATERIALS AND METHODS

Experiment-1: Six varieties of hybrid maize [PMH-1 grain (V_1), Bulland (V_2), African Tall (V_4), Dekalb 7074 Monsanto (V_5), Proagro 4640 (V_6), Egyptian variety G-

5414 (V_7)] and one composite maize variety J1006 (V_3) were cultivated without fertilizer (F_1), with *Azotobacter* treated seed (F_2), recommended dose of fertilizer (F_3), or $F_2 + F_3$ (F_4) with three replicates at University fodder production area of Department of Animal Breeding and Genetics, GADVASU, Ludhiana. The sowing was done in 30 cm apart rows with plant to plant spacing of 20 cm. The net plot size was 9.6 m^2 (2.4 × 4 m), each plot had 8 lines containing 20 plants per row. Herbicide atrazine was applied as pre-emergence @ 1.0 kg/ha to control the weeds in crop. The soil of the experimental field was loamy sand in texture, low in available nitrogen and phosphorus and high in available potash. Therefore, recommended dose of fertilizer, i.e. 60 kg N and 30 kg P_2O_5/ha was applied at the time of sowing (Anonymous 2010).

Nutritional evaluation of leftover fodder: The fodder from different maize hybrids (7) cultivated with different fertilizers (4) in three replicates was evaluated by *in vitro* gas production technique (IVGPT) in triplicate (Menke *et al*. 1979, Menke and Steingass 1988). The data were analyzed by 7 × 4 factorial design (Snedecor and Cochran 1994) by using SPSS (2009) version 16.0 and the means were tested for the significant difference by using Duncan's multiple range test.

Experiment-2: Comparative evaluation of conventional maize fodder and baby corn fodder in TMR: Two TMRs containing either conventional maize fodder or baby corn fodder were formulated. Both the TMRs contained concentrate mixture, conventional maize or baby corn fodder and wheat straw in 42: 44: 14 ratio on DM basis. The finely ground samples of both the TMRs were analyzed for proximate and cell wall constituents. The nutritional value of TMRs was evaluated by IVGPT.

In vivo *evaluation:* A 45-d feeding trial was conducted on 8 male Murrah buffalo calves (live weight 127.63±3.63 kg). The animals divided into 2 equal groups were offered TMRs containing concentrate mixture, either BC fodder or conventional maize fodder and wheat straw in 44: 42: 14 ratio on DM basis as per NRC (2001). The formulated concentrate mixture used in the TMR contained maize 20, wheat 15, deoiled mustard cake 10, mustard cake 10, soybean meal 15, rice bran 15, deoiled rice bran 12, common salt 1 and mineral mixture 2 parts each. A seven days metabolism trial was conducted before the termination of the experiment.

Analytical methods: The finely ground samples of feedstuffs, orts and faeces were analyzed for proximate components (AOAC 2007), cellulose (Crampton and Maynard 1938) and other cell wall constituents (Van Soest *et al.* 1991). Hemi-cellulose was determined by difference in NDF and ADF. The urine samples were analysed for total-N (AOAC 2007). Volatile fatty acids (VFAs) production in the *in vitro* fermentation media were also estimated by using GLC (Cottoyn and Boucque 1968). Methane produced during the *in vitro* fermentation in the syringes was estimated by using the equation based on VFA proportions (Widiawati and Thalib 2009). The data were analyzed by using one way ANOVA (Snedecor and Cochran 1994) by using SPSS (2009) version 16.0 and the means were tested for the significant difference by using Tukey's b test.

RESULTS AND DISCUSSION

Experiment 1: Quality parameters of baby corn cob: The length of cob with husk and silk, that of cob with husk and that of cob only was the lowest ($P<0.01$) in Bulland variety and the highest ($P<0.01$) was observed in J-1006

Table 1. Effect of different cultivated maize hybrids and fertilizers on the physical parameters of baby corn and on leftover fodder yield

Parameter	Varieties of baby corn tested (V)								Type of fertilizers used (F)				PSE
	V_1	V_2	V_3	V_4	V_5	V_6	V_7		F_1	F_2	F_3	F_4	
L-1	32.64^c	27.21^a	32.78^c	31.98^{bc}	31.11^{bc}	28.88^{ab}	30.37^{bc}	0.75	29.78^A	30.95^{AB}	30.15^{AB}	31.95^B	0.63
L-2	25.42^e	20.40^a	25.48^e	24.01^d	22.87^c	21.27^{ab}	21.99^{bc}	0.23	22.66^A	22.98^A	22.70^A	23.68^B	0.21
L-3	10.17^b	9.43^a	11.23^d	10.96^{cd}	10.25^b	10.55^{bc}	9.59^a	0.12	10.04^A	10.19^A	10.50^B	10.52^B	0.10
G-1	8.62^b	8.34^b	8.75^b	8.44^b	7.49^a	7.85^a	7.72^a	0.10	8.14	8.23	8.16	8.17	0.08
G-2	5.95^b	7.07^c	5.97^b	5.99^b	5.06^a	5.20^a	5.06^a	0.16	5.58	5.74	5.84	5.86	0.14
W-1	74.18^b	56.11^a	72.59^b	66.38^b	48.93^a	51.56^a	51.50^a	1.85	57.97^A	61.08^{AB}	59.75^A	61.92^B	1.50
W-2	17.11^b	22.49^c	22.22^c	21.25^c	14.40^{ab}	15.15^{ab}	12.86^a	0.63	17.02	18.26	18.65	17.78	0.52
W-3	57.07^d	33.62^a	50.37^{bc}	45.13^b	34.53^a	36.41^a	38.64^a	1.39	40.95^A	42.82^A	41.10^A	44.14^B	1.16
W-4	76.93^c	59.92^a	69.39^b	67.99^b	70.57^b	70.62^b	75.03^c	1.15	70.64^{AB}	70.10^A	68.79^A	71.29^B	0.95
FY	284.75^{bcd}	333.13^d	327.33^d	313.91^{cd}	214.51^a	232.51^{ab}	256.89^{abc}	15.50	268.12	270.76	298.74	283.92	11.72

V_1, PMH1; V_2, Bulland; V_3, J1006; V_4, African tall; V_5, DeKalb 7074 Monsanto, V_6, Proagro 4640 (Bharti Dolmento); V_7, Baby corn G-5414 (Bharti Dolmento); F_1, Control (No fertilizer); F_2, Azotobacter treated seed only; F_3, Recommended dose of fertilizer for baby corn (60 kg N and 30 kg P_2O_5/ha at the time of sowing); F_4, Recommended rate of fertilizer + *Azotobacter* treated seed, L-1, Length of cob with husk and silk, cm; L-2, Length of cob with husk only, cm; L-3, Length of edible cob only, cm; G-1, Girth of cob with husk, cm; G-2, Girth of cob without husk, cm; W-1, Weight of cob with husk, g; W-2, Weight of cob without husk, g; W-3, Weight of husk only, g; W-4, Weight of husk, as % of weight of cob with husk; FY-Fodder yield, q/ha; Means with different superscripts^{a,b,c} for different varities of baby corn and superscripts$^{A, B, C}$ for different fertilizers used within a row differ significantly; PSE, Pooled standard error.

variety (Table 1). The values reported earlier (Kumar *et al.* 2015, Singh *et al.* 2015) were considerably lower than those obtained in the present study. The length of cobs of traditional baby corn varieties was comparable to that of Bulland variety. The length of the ears and the girth of cob with husk was comparable in V_1 to V_4, but higher than that of V_5 to V_7 varieties. The girth of cob without husk was the highest ($P<0.05$) in Bulland variety than all other varieties. It was followed by that of V_1, V_3 and V_4 varieties which had comparable diameter of cob without husk; but higher ($P<0.05$) than that of V_5 to V_7 varieties, which in turn were comparable. Earlier studies (Kumar *et al.* 2015, Singh *et al.* 2015) revealed lower girth of cobs without husk as compared to the present values. The weight of cob with husk was the lowest ($P<0.01$) in V_5 variety comparable with V_2, V_6 and V_7, but significantly lower than V_1, V_3 and V_4, which were comparable. The weight of edible cob without husk, fit for human consumption was the highest ($P<0.01$) in V_2 followed ($P<0.01$) by V_1 and lowest ($P<0.01$) weight of cob without husk was observed in V_7. Singh *et al.* (2015) reported lower weight of cobs without husk and silk as compared to the present values. The weight of the husk was the highest ($P<0.01$) in V_1 followed by V_3 and V_4 varieties. The weight of husk was comparable in all the remaining varieties. Weight of husk, as per cent of weight of cob with husk was the highest ($P<0.01$) in V_1 comparable with that of V_7 and the lowest weight was recorded in V_2, while the weight of husk of remaining varieties was comparable and in between. The fodder yield was the highest in V_2 comparable with that of V_1, V_3 and V_4. The lowest ($P<0.01$) fodder yield was recorded in V_5 which was comparable with that of V_6 and V_7. Earlier Kumar *et al.* (2015) reported that fodder yield of 6 different baby corn varieties varied between 107.55 to 266.9 q/ha, which was considerably lower than the one obtained in the present study. However, Singh *et al.* (2015) reported that leftover fodder yield varied from 308 to 375 q/ha.

Organic sources of fertilizers application on soil not only amended the crop productivity but also sustain and maintain the soil physical and chemical properties such as organic carbon, water holding capacity along with supplying N, P and K (Singh *et al.* 2017). These also help in making unavailable sources of elemental nitrogen, fixed phosphates, micronutrients, and decomposed plant residues into an available form to aid to plant to absorb the nutrients (Kumar *et al.* 2014). These also cause reduction in cost of cultivation as well enhance nutrition value of the sink without any residual toxicity which can influence human health and moreover maintain ecological balance.

The effect of different fertilizers on the physical parameters irrespective of the varieties revealed that the length of cob with husk and silk, cob with husk and that of edible cob only was higher ($P<0.01$) in the group cultivated with F_4 as compared to all other groups cultivated with or without fertilizers (Table 1). The length of cobs with or without husk and silk was comparable in groups cultivated with (F_2 and F_3) or without (F_1) fertilizers, except that the length of cob (without husk and silk) was comparable in groups cultivated with F_3 and F_4 fertilizers. The weight of cob with husk, was the highest ($P<0.01$) in group cultivated with F_4 fertilizer as compared to all other groups. Hekmat and Abraham (2016) advocated that addition of organic sources had significant influence on all yield parameters and also yield of cob and fodder of baby corn.

The weight of cob with husk, was comparable in groups cultivated with (F_2 and F_3) or without (F_1) fertilizers. The weight of edible cob without husk, fit for human consumption was not affected by the type of fertilizer used. The weight of the husk was the highest ($P<0.01$) in group cultivated with F_4 fertilizer as compared to all other groups. The weight of husk was comparable in groups cultivated with (F_2 and F_3) or without (F_1) fertilizers. Weight of husk, as per cent of weight of cob with husk was the highest ($P<0.01$) in F_4 comparable with that of F_1 as compared to groups cultivated with other fertilizers. The fodder yield was comparable in all the groups and was not affected by the type of fertilizer used.

The effect of different varieties on the chemical

Table 2. Effect of different cultivated maize hybrids and fertilizers on the chemical composition of leftover baby corn fodder, % DM basis

Parameter	Varieties of baby corn tested (V)*							PSE	Type of fertilizers used (F)*				PSE
	V_1	V_2	V_3	V_4	V_5	V_6	V_7		F_1	F_2	F_3	F_4	
Ash	5.80	5.66	5.69	5.33	5.43	5.91	5.61	0.16	5.49	5.61	5.81	5.63	0.14
OM	94.20	94.34	94.31	94.67	94.57	94.09	94.39	0.61	94.51	94.39	94.19	94.37	0.14
CP	8.29^{b}	8.07^{ab}	7.73^{ab}	7.61^{ab}	6.83^{a}	7.74^{ab}	8.50^{b}	0.29	7.32^{A}	7.17^{A}	8.18^{B}	8.63^{B}	0.25
NDF	69.30	68.28	66.83	67.06	67.85	68.05	70.20	1.45	69.60	67.52	66.41	69.36	1.24
ADF	37.30	37.01	38.51	38.78	39.58	40.89	37.50	1.07	38.09	39.76	37.28	38.91	0.91
HC	32.00	32.28	28.72	28.28	28.28	27.16	32.70	1.71	31.51	28.34	29.13	30.45	1.46
Cellulose	32.90	32.01	31.18	31.18	31.19	30.74	31.32	0.72	31.00	30.21	32.62	32.20	0.62
EE	1.78	1.50	1.52	1.52	1.36	1.42	1.51	0.09	1.51	1.64	1.47	1.45	0.08
ADL	3.51	3.73	3.63	3.51	3.82	3.31	3.63	0.27	3.98	3.27	3.30	3.81	0.23

*See footnote of Table 1. OM, Organic matter; CP, Crude protein; NDF, Neutral detergent fibre; ADF, Acid detergent fibre; HC, Hemicellulose; EE, Ether extract; ADL, Acid detergent lignin. Means with different superscripts^{a,b,c} for different varities of baby corn and superscripts$^{A, B, C}$ for different fertilizers used within a row differ significantly; PSE, Pooled standard error.

Table 3. Effect of different cultivated maize hybrids and fertilizers on the *in-vitro* net gas production, digestibility of nutrients and ME of leftover fodder

Parameter	Varieties of baby corn tested (V)*							PSE	Type of fertilizers used (F)*				PSE
	V_1	V_2	V_3	V_4	V_5	V_6	V_7		F_1	F_2	F_3	F_4	
NGP	178.75^c	192.60^d	180.68^c	174.89^b	181.48^c	169.33^a	189.88^d	1.23	195.09^D	183.41^C	178.27^B	167.59^A	0.93
NDFD	38.04^d	46.79^f	40.86^e	33.19^a	36.35^c	34.58^b	47.86^f	0.33	44.71^D	39.2^B	40.84^C	33.82^A	0.25
TOMD	55.61^c	60.82^e	56.24^d	53.85^b	56.12^{cd}	53.00^a	60.60^e	0.24	59.12^D	56.17^B	57.33^C	53.8^A	0.175
PF	2.14^c	1.91^a	2.06^{bc}	2.11^c	1.96^{ab}	2.18^c	1.96^{ab}	0.03	1.95^A	2.02^A	2.03^A	2.19^B	0.06
ME	6.83^a	7.29^b	6.92^a	6.78^a	6.94^a	6.73^a	7.24^b	0.08	7.24^B	6.96^A	6.85^A	6.79^A	0.06

*See foot note of Table 1. NGP, Net gas production ml/g DM/24 h; NDFD, Neutral detergent fibre digestibility %; TOMD, True organic matter digestibility %; PF, Partitioning factor; ME, Metabolizable energy MJ/kg DM. Means with different superscripts^{a,b,c} for different varities of baby corn and superscripts$^{A, B, C}$ for different fertilizers used within a row differ significantly; PSE, Pooled standard error.

composition of fodder irrespective of the fertilizer used revealed that there was no difference in the proximate and cell wall constituents of different varieties except the CP content (Table 2), which was the significantly ($P<0.01$) higher in V_7 as compared to V_5, but statistically comparable with all other varieties. The effect of different fertilizers, irrespective of the varieties, had no significant effect on the proximate and cell wall constituents' composition of leftover fodder, except that on CP content (Table 2). The CP content was the highest ($P<0.01$) in groups cultivated by using F_4 fertilizer, comparable with that of F_3 cultivated varieties, but significantly higher ($P<0.01$) than those cultivated without fertilizer (F_1) or F_2.

In vitro *evaluation:* The effect of different varieties on the *in vitro* nutritional evaluation of fodder, irrespective of the fertilizer used revealed that the net gas production was the highest in V_2 which was comparable with Egyptian variety G-5414 (V_7), but significantly higher ($P<0.01$) than V_5 and the rest of the tested varieties (Table 3). It was observed to be the lowest in V_6 variety. The digestibility of NDF and true OM was the highest in V_7, comparable with V_2 variety, but significantly higher ($P<0.01$) than V_3 and the rest of the tested varieties. The lowest digestibility of NDF was observed in V_4, while that of true OM was in V_6. The PF was the highest in V_6, comparable with that of V_1, V_3 and V_4, but significantly higher ($P<0.01$) than V_2, V_5 and V_7 varieties. The available ME was the highest in V_2, statistically comparable with V_7, but significantly higher ($P<0.01$) than the rest of the tested varieties.

The effect of different fertilizers, on the *in vitro* nutritional evaluation of fodder, irrespective of the varieties revealed that net gas production, digestibility of NDF and true OM; and ME availability were depressed significantly ($P<0.01$) in the groups supplemented with different fertilizers as compared to control without any fertilizer group (Table 3). However, PF was significantly higher ($P<0.01$) in group in which F_4 was used as compared to all other tested fertilizers.

Experiment-2: In vitro *and* in vivo *evaluation of TMRs:* The chemical composition of two TMRs containing either conventional maize fodder or baby corn fodder revealed that proximate as well as cell wall constituents contents were comparable except that ADF content was higher ($P<0.05$) in TMR containing BC fodder than maize fodder (Table 4). Both the TMRs were iso-nitrogenous and iso-caloric. The *in vitro* evaluation revealed that the NGP, digestibility of nutrients, VFAs and ME availability were comparable in both the TMRs (Table 4). Chaudhary *et al.* (2016) tested five maize genotypes for their forage quality and *in vitro* DM digestibility. Forage maize (J-1006) and baby corn hybrid (HM-4) were at par with respect to forage quality parameters. Further, the correlation data showed that CP was positively related to IVDMD but negatively associated with fibre components (CF, NDF and ADF). Shanti *et al.* (2012) reported that the fodder of baby corn was found to be superior with respect to crude protein content, while other parameters, viz. crude fibre and *in vitro* DM digestibility were commendable. Though the fodder yields were lesser in baby corn, the revenue from baby cobs

Table 4. Chemical composition and *in vitro* evaluation of total mixed ration containing either maize fodder or baby corn fodder, % DM basis

Parameter	TMR-1	TMR-2	Pooled SE
Total ash	7.00	6.88	0.06
OM	93.00	93.12	0.06
EE	1.95	1.85	0.04
CP	13.29	13.50	0.09
NDF	67.2	66.4	0.26
ADF	41.45^a	42.45^b	0.30
Hemicellulose	25.75	23.95	0.56
Cellulose	26.00	26.30	0.26
In vitro evaluation			
NGP*	165.77	165.33	1.94
NDFD	39.88	35.14	1.57
TOMD	57.66	54.93	1.92
PF	2.203	2.202	0.23
TVFAs	5.19	5.16	0.14
ME	7.00	6.99	0.14

TMR-1 contained conventional maize fodder; TMR-2 contained baby corn fodder; TVFAs, Total volatile fatty acids mM/dl; ME, Metabolizable energy MJ/kg DM. *See foot note of Table 3.

Table 5. Digestibility of nutrients and N-retention in buffalo calves fed total mixed ration containing either maize fodder or baby corn fodder

Parameter	TMR-1	TMR-2	Pooled SE
DM intake, kg/day	3.34	3.22	0.18
Digestibility of nutrients, %			
DM	50.14	59.17	4.11
OM	53.92	62.45	3.86
CP	55.43	55.08	2.41
NDF	45.64	55.36	4.72
ADF	30.95	43.08	5.66
Cellulose	39.96	43.77	4.86
Hemicellulose	57.41	63.75	4.21
N-balance, g/day			
N-intake	70.93	71.06	2.56
Faecal-N	15.5	15.98	1.69
Urinary-N	28.34	29.45	2.22
N-retained	27.09	25.63	3.58
N-retained as % of absorbed	47.16	46.4	5.06

TMR-1 contained conventional maize fodder; TMR-2 contained baby corn fodder.

especially in urban and peri-urban areas brought higher returns. The net returns were ₹ 39,750/ha from baby corn. The economics through net returns and B:C ratio indicated baby corn > fodder crop > seed crop > green cob. Besides baby corn provides an added advantage. Shekara *et al.* (2015) also reported that maize grown for either green cob or baby corn intercropped with cowpea (fodder) round the year is more remunerative than cultivation of perennial Napier bajra intercropping with cowpea/lucerne to meet the fodder requirement in peri-urban area of Karnataka.

The *in vivo* studies conducted on male buffalo calves revealed that the daily DM intake was comparable, digestibility of proximate and cell wall constituents was considerably higher in calves fed TMR containing baby corn fodder (Table 5). The N-intake, digestible-N, N-retained and efficiency of nitrogen utilization were statistically comparable in both the TMRs.

The results clearly indicated that baby corn fodder can be utilized efficiently by the ruminants. Further, besides getting handsome amount by selling baby corn cobs for human consumption, the dairy farmers can get additional income by feeding husk with silk and baby corn fodder to dairy cattle, thereby can bridge the gap between demand and supply of green fodder to certain extent.

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