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Impact of Bio-Fortified Maize on Silage Quality, Milk Production and Economics in Mild-Tropical Humid Climate of Tripura

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ABSTRACT

Bio-fortified maize is supplemented with high-quality protein and contains appreciable amounts of tryptophan, lysine and pro-vitamin A than the conventional maize varieties and hybrids. Hence, cultivation of bio-fortified maize as food-feed crop may enhance quality of feed-fodder and milk in addition to improvement in productivity and income of farmers. A study was conducted with 5 varieties at 3 locations in the South Tripura district during the kharif and rabi seasons of 2020-21, including three bio-fortified maize hybrids (LQMH 1, Vivek QPM 9 Improved and HQPM 5 Improved), a traditional hybrid (Sujata) and a high yielding composite variety (DA 61A). The purpose of the study was to determine the usefulness of bio-fortified maize in terms of production, its acceptability as feed and its effects on milk production and farmer income. In comparison to the high yielding composite variety, bio-fortified maize's performance was determined to be suitable, with greater yield (3.23-4.15 t ha^{-1}) and B:C ratio (2.02-2.59:1). However, highest yield (4.23 t ha^{-1}) and B:C ratio (2.64:1) was recorded with traditional hybrid (Sujata). Utilizing bio-fortified green fodder maize to prepare silage increased net return by 80 to 98% above conventional maize grain production. The quality silage prepared using green maize was good because of its sweet and sour, faint green or brownish colour and acidic pH (3.60-4.20). Silage feeding to dairy animals for a continuous four months raised average milk production by 38.2 to 53.1%, resulting in an increase in daily income cow^{-1} of Rs. 190 to Rs. 255. Due to its suitability as feed-fodder, milk production, income and socio-economic status of the farmers, the cultivation of bio-fortified maize and the preparation of feeds for dairy animals might be advised for the dairy farmer in mild-Tropical humid climate of Tripura.

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INTRODUCTION

The South Tripura district of Tripura lies between 22°72′ N to 23°28′ N longitudes and 90°55′ E to 91°16′ E latitude with an elevation of 120 m above mean sea level. The district's cross cropped area and net sown area are 73,135 ha and 41,884 ha, respectively, with a cropping intensity of 175%. Over 96% of farmers are small and marginal. Besides agricultural operations, dairy farming is quite popular in the district; however, milk production is very low due to traditional feeding practices and a lack of feeding availability during lean seasons. Maize (*Zea mays* L.) is one of the most versatile and multi utility crops, with greater adaptation in a wide range of ecological situations. It is a major source of food, feed, fodder and industrial raw material and it also provides tremendous opportunities for crop diversification, value addition and employment generation. Agro-climatic condition and adequate annual rainfall (1989 mm) distributions of South Tripura district are ideal for year-round maize growing. Because the majority of farmers are small, marginal, or landless, their income level is relatively low for a sustainable livelihood. For that reason, scientific dairy animal rearing in conjunction with maize-based farming may be a viable option for enhancing their annual farm income. Compared to normal maize varieties and hybrids, bio-fortified maize is rich in provitamin-A (8.15 ppm) and having high quality protein that contains tryptophan (0.74-0.80%) and lysine (2.67-3.5%). Therefore, cultivation of bio-fortified maize as a food-and-feed crop may improve the quality of milk and feed, as well as increase farmer productivity and income. In order to meet year-round feeding requirements for dairy animals, year-round maize growing, along with other perennial fodders, may be popularized among dairy farmers in the district, as the technology required in maize production and processing is quite simple and easily acceptable.

MATERIALS AND METHODS

Demonstration programme on fortified maize cultivation was conducted at three villages of South Tripura district during the *kharif* and *rabi* seasons of 2020-21. Shri Sajal Dey, age 44, a maize planter from Purba Charakbai village of South Tripura, has been chosen for the fortified maize demonstration. Previously, he supported his family through wage labour and secondary agricultural operations such as dairy and poultry rearing. In 2019, he leased 2 ha of land (@ Rs. 18,750.00 ha^{-1} $year^{-1}$) for the production of fodder for animal husbandry and began year-round maize cultivation, along with other perennial fodder crops for feeding of his dairy animals. Prior to promoting bio-fortified maize farming, he was taught by KVK scientists in several technologies of scientific animal husbandry and fodder production to better comprehend and capitalize on its benefits. He took part in training and demonstration programmes connected to dairy feeding and health care management. All necessary inputs, such as maize (fortified varieties) and cowpea seeds, slip of perennial fodder crops, small tools and implements and need-based fertilizers were also provided to him for adopting fodder-based farming practices. Though, his annual fertilizer requirement was negligible, because the majority of soil nutritional requirements were met by using cow manure. To ensure the availability of fodder for dairy cows throughout the year, he was advised for staggered sowing of maize. During the demonstration programme, special attention was placed on fortified maize cultivation. The seeds of fortified maize were received from ICAR, Tripura centre under DBT sponsored project. Besides bio-fortified maize varieties (LQMH 1, Vivek QPM 9 Improved and HQPM 5 Improved), HYV (DA 61A) and Hybrid (Sujata) maize varieties were also cultivated based on the requirement. The demonstration plots were monitoring on regular basis and suggestions were provided to the farmers as needed. Later, he was educated how to make silage from fully nutritious maize fodder. After receiving full knowledge of silage preparation by the farmer, a chop cutter machine was made available by spending of Rs. 40,000.00 to begin silage preparation. Adequate quantities of silage were stored for feeding of dairy animals throughout the year. Initially, he was encouraged to prepare silage for his own use, but eventually he began selling to dairy farmers both within and outside the district, particularly during

lean periods. Chaffed maize green fodder was fermented in anaerobic conditions during the silage preparation procedure. To make high-quality silage, green maize fodder was harvested when the cobs were 50% maturity stage and some quantities of salt, jaggery and mineral mixture were also added during process of silage preparation. Ready silage of each variety was initially offered to the animals at a rate of 5 kg per day by combining it with chaffed green fodder to establish taste among the animals. When the animals began to like the sweet-sour taste of the silage, the silage dose was increased to 20 kg day^{-1}cow^{-1}.

RESULTS AND DISCUSSION

Performance of Maize Varieties and Economics at South Tripura Agro-Ecological Situations

Five maize varieties, including three popular bio-fortified maize hybrids (LQMH 1, Vivek QPM 9 Improved and HQPM 5 Improved), a traditional hybrid (Sujata) a high yielding composite variety (DA 61A), were cultivated to determine yield performance in the district as well as suitability of those varieties for silage preparation. Experiment indicated that the grain yield of the maize varieties ranged from 3.20 to 4.23 t ha^{-1} (Table 1). Among the tested varieties hybrid-sujata (4.23 t ha^{-1}) and bio-fortified HQPM 5 improved variety (4.15 t ha^{-1}) were having higher yield, also showed greater crop duration. The DA 61A maize cultivars produced the lowest yield (3.20 t ha^{-1}). Yield of bio-fortified maize varieties ranged from 3.23 to 4.15 t ha^{-1}, which was 48 to 55% lower than the potential yield of those varieties. A larger yield gap between average farmer produce and potential maize yield may be due to many factors, including uncontrollable factors (precipitation, temperature, radiation, *etc.*), soil quality, inefficient crop management practices and social and economic issues (Lobell *et al.*, 2009). The tested maize varieties (bio-fortified and hybrid) had better gross returns (Rs. 64,600.00 to Rs. 84,600.00 ha^{-1}) and net returns (Rs. 32,600.00 to Rs. 52,600.00 ha^{-1}) than the farmers' practice variety of DA 61A (Rs. 64,000.00 ha^{-1} and Rs. 32,000.00 ha^{-1}). The B:C ratios (2.02-2.64:1) of the bio-fortified and hybrid maize varieties were both noticeably higher than those of the commonly grown farmer's variety (2.00:1).

Table 1: Performance of maize varieties and economics

Varieties	Type of breed	Crop performance and economics				
		Days to maturity (days)	Grain yield (t ha^{-1})	Gross Returns (Rs.)	Net Returns (Rs.)	B:C ratio
LQMH 1	Bio-fortified hybrids	78	3.62	72,400	40,400	2.26:1
Vivek QPM 9 Improved	Bio-fortified hybrids	72	3.23	64,600	32,600	2.02:1
HQPM 5 Improved	Bio-fortified hybrids	100	4.15	83,000	51,000	2.59:1
Sujata	Hybrid	85	4.23	84,600	52,600	2.64:1
DA 61 A	HYV	80	3.20	64,000	32,000	2.00:1
SE (±)		10.42	0.49			

Preparation of Maize Silage and Changes in Economic Returns

Silage preparation is a vital way for storing green fodder for dairy animals and it is necessary to adopt this method by the dairy farmers for preservation of feeds for lean period of year as well as the situations like drought or heavy rainfall or scarcity of fodder. Estimation (Table 2) indicated that 15.0 to 23.75 t green biomass of maize could be harvested from 1 ha area and from that 13 to 21 t of mature silage could be produced, if green maize harvested at 50% cob maturity stage. Because maize contains more sugar than proteins at this stage and sugar is used in the fermentation process by microbes to produce

lactic acid, which aids in the preservation of green fodder for longer periods of time. The conversion weight loss from green biomass to silage preparation was from 9.3 to 13.3% depending on maturity, moisture content and humidity at the harvesting stage of green fodder.

Table 2: Green biomass, silage production and economics

Varieties	Wt. of Green Biomass (t ha^{-1})	Wt. of silage (t ha^{-1})	Weight loss (%)	Gross Returns (Rs. kg^{-1}) @ Rs. 10.00 kg^{-1}	Total Cost of Production		Net Returns (Rs.)	Additional income (Rs.)
					Cultivation cost (Rs. ha^{-1})	Silage preparation cost (Rs.)		
LQMH 1	20.0	18.0	10.0	1,80,000	32,000	68,000	80,000	39,600
Vivek QPM 9	15.0	14.2	9.30	1,42,000	32,000	51,000	59,000	26,400
HQPM 5	23.0	20.5	10.9	2,05,000	32,000	78,200	94,800	43,800
Sujata	23.75	21.0	11.6	2,10,000	32,000	80,750	97,250	44,650
DA 61 A	15.0	13.0	13.3	1,30,000	32,000	51,000	47,000	15,000

The total gross returns per ha increased from Rs. 1,30,000.00 to Rs. 2,10,000.00 due to silage preparation by utilizing green maize fodder, while net returns also improved by Rs. 47,000.00 to Rs. 97,250.00 due to value addition of maize. The additional production cost (Rs. 51,000.00 to Rs. 80,750.00) of maize fodder silage preparation was due to employment of labour (125 nos. ha^{-1}), electricity charges of chop cutter (Rs. 10,000.00), HDPE bags for airtight packaging, salt, jaggery, mineral mixture, *etc*. However, silage preparation offered additional net returns by Rs. 15,000.00 to Rs. 44,650.00 ha^{-1}.

Quality of Maize Silage

Silage is typically ready for animal feeding after 8-10 weeks, but when green maize fodders were utilized to prepare the silage, it was ready for animal feeding in just 43-53 days (Table 3). Silage that had been processed had sweet and acidic in taste that suggested the produce is good in qualities. Similarly, colour of the ready was determined to be faint green or brownish, no silage of a black colour was observed. Mature silage had a pH range of 3.60 to 4.20, indicating that it was acidic in nature.

Table 3: Quality of silage prepared using different maize varieties

Variety used for silage preparation	Duration of silage preparation	Odour	Colour	pH	Preference by the animals as per farmers opinion
LQMH 1	43	Sweet	Faint green or brownish	4.20	Good
Vivek QPM 9	45	Sweet & Sour	Faint green or brownish	3.90	Very good
HQPM 5	53	Sour	Faint green or brownish	3.70	Good
Sujata	52	Sour	Faint green or brownish	3.60	Good
DA 61 A	49	Sweet	Faint green or brownish	3.95	Good

All the quality parameters of the prepared silage were found perfect for feeding dairy animals. According to Mc Donald *et al.* (2000), high milk production and milk quality are encouraged by silage quality at all lactation phases.

Impact of Silage Feeding on Milk Production

Maize silage is an excellent high energy supplementing feeds, since it retains the nutrients in their natural state, making it just as good for animal feeding as green fodder (Chaudhary *et al.*, 2014).

The average milk production ranged from 9.6 kg animal^{-1}day^{-1} to 10.2 kg animal^{-1}day^{-1} in animals fed green fodder, with an overall average of 9.8 kg animal^{-1}day^{-1}. In was observed that silage feeding to dairy animals for continuous four months increased average milk production animal^{-1}day^{-1}, ranging from 13.6 kg animal^{-1}day^{-1} to 14.7 kg animal^{-1}day^{-1}, with an overall average of 14.8 kg animal^{-1}day^{-1} (Table 4). It was also calculated that replacing of feed green with maize silage enhanced cow milk production by 38.2% to 53.1%. The palatability of fodder crop enhanced during silage production because the hard stem softens during fermentation in silage, allowing dairy animals to digest it more easily. Furthermore, anti-quality components like nitrate are either destroyed or reduced during silage fermentation (Chaudhary *et al.*, 2014). When green fodder was supplemented with maize silage, the average daily income per cow increased from Rs. 190.00 to Rs. 255.00.

Table 4: Impact of silage feeding on milk production

Variety used for silage preparation	No. of cow tested (n)	Average daily milk production cow^{-1} with normal feeding (litre)	Average daily milk production cow^{-1} with silage feeding (litre)	Changes in milk production (%)	Changes in Income (Rs. day^{-1})
LQMH 1	5	9.8	14.2	44.9	220
Vivek QPM 9 Improved	5	9.6	14.7	53.1	255
HQPM 5 Improved	5	10.2	14.1	38.2	195
Sujata	5	9.6	13.8	43.8	210
DA 61 A	5	9.8	13.6	38.8	190
SE (±)		0.33	0.63		

Adoption of Technology and Benefits

The extension interventions made by KVK, South Tripura in Purba charakbai village has inspired the farmer by the method of cultivation and processing procedures that helped him achieve greater production and economy. As a result, nearby dairy farmers are encouraged to start maize growing and silage preparation for feeding their dairy animals.

CONCLUSION

According to the findings of this study, the yield performance of fortified maize varieties in the South Tripura district is fairly satisfactory and highly appropriate for silage production. Furthermore, feeding maize silage at a rate of 20 kg per animal per day might increase milk output in dairy cows by 38 to 53%. For the benefit of livestock farmers in this area, advanced research to analyze the influence of silage feeding on milk quality parameters, as well as evaluation of various crops for silage quality should be undertaken.

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Conflict of Interest

The authors declare no conflict of interest.

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