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Maize (*Zea mays*) cultivars evaluation for herbage yield and silage quality

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ABSTRACT

A field experiment was conducted during spring 2019 under on farm trials at commercial dairy farms in Tarn Taran district of Punjab (India) under subtropical conditions. The three cultivars of corn (*Zea mays* L.), i.e. J 1006, PMH 10 and DKC 9108 were evaluated for their silage production potential. The cropping system followed by farmers was paddy-pea-spring maize (Silage making). Fodder yield, factor productivity, net return and economic productivity were recorded higher under maize hybrid PMH 10 which was found at par with hybrid DKC 9108 and significantly higher than cultivar J 1006. Silages prepared from hybrids PMH 10 and DKC 9108 recorded significantly better ($P<0.05$) fermentation characteristics, nutritive value and feed values in comparison to silage of composite J1006. Thus, under intensive cropping system, PMH 10 and DKC 9108 hybrids of corn are best suitable for cultivation during spring season for quality silage production.

Keywords: Cultivars, Nutritive value, Silage, Yield

Quality fodder availability is most important factor for sustainable and economical livestock production (Brar *et al*. 2017, Kumar *et al*. 2019). The increasing cultivation of cereals and cash crops resulted in shrinking of the land for fodder cultivation thus major constraints in improving green fodder production (Chaudhary *et al*. 2016). Under tropical climatic conditions, farmers are facing the shortage of fodder during the months of May-June and November-December, and they have to feed straws and stover's along with the costly concentrates to fulfil the daily dietary requirement of milking animals. In silage production, entire crop is harvested when the nutrient contents in fodder crop is at peak, is the best method to suffice the shortage of green fodder and helps in sustaining the round the year fodder availability for dairy animals. Practice of silage making is now a well established practice in the temperate region of North America, Europe and also becoming popular in tropical regions (Wilkins and Wilkinson 2015).

Maize (*Zea mays* L.) is the most suitable crop for silage preparation because of its relatively constant nutritive value, high yield and having high concentration of soluble carbohydrates for fermentation to lactic acid (Darby and Lauer 2002, Hundal *et al*. 2019). In order to obtaining sustainable yield of quality maize fodder for silage making under a particular climate conditions, cultivar selection is an important practice (Ileri *et al*. 2018, Brar *et al*. 2019a). Under subtropical conditions of Punjab state of India, most of the commercial dairy farms preparing silage are following Paddy-Pea/Toria-Spring Maize (silage making) cropping systems, in which after harvesting of *rabi* crop (pea or toria), a time period of only 80-90 days is left for the cultivation of spring maize for silage making, before transplanting of paddy during next season. Farmers are generally growing maize hybrids available in the market with costly seed which varies in their performance (yield and quality) during limited time for their cultivation. Thus the present study was carried out with the objectives to provide most production efficient and economical cultivar of spring maize to the farmers for silage making.

MATERIALS AND METHODS

A field study was carried out during spring 2019, under On Farm Trials at three commercial dairy farms of Tarn Taran district of Punjab (India). The intensive cropping system followed by farmers was paddy-pea-spring maize (silage making). The soils of experimental fields were loamy in texture having medium organic carbon status, fairly good in available P, rich in available K and medium in availability of micronutrients, viz. Zn, Fe and Mn.

The three corn cultivars were selected for study, i.e. J 1006, PMH 10 and DKC 9108. Among these maize cultivars, J1006 is composite variety recommended for fodder production, while PMH 10 is spring maize hybrid

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for grain production, both developed by Punjab Agricultural University, Ludhiana, India. The maize hybrid DKC 9108 is of Monsanto seeds also recommended by PAU, Ludhiana for the cultivation in irrigated conditions of Indian Punjab. The crop was sown during second week of March on the southern side of east-west ridges 60 cm apart by dibbling seed manually keeping plant to plant distance 20 cm. Seed rate was kept 20 kg/ha. A dose of 250 kg of Urea/ha and 125 kg DAP/ha was applied to the crop. Half dose of urea and whole DAP was applied at the time of sowing and remaining half dose of urea was applied as top dressing when crop was at knee height stage. For control of grassy weeds, 1500 g/ha Atrazine + 2.5 L/ha Pendimethalin was applied within two days after sowing and for control of *Cyperus rotundus* and broad leaf weeds, 1.0 L/ha of 2,4-D (amine salt) was applied at 20-25 DAS. Crop was harvested by using single row maize harvester at 85 days after planting. At the time of harvesting, PMH 10 and DKC 9108 were at milk stage to dough stage (when milk line was 1/3 to ½ down the kernel) while J1006 was at blister stage. The corn cob mixture silage was prepared by farmers in silo bunkers having varying dimensions while for study purpose, the fodder of each cultivar was ensiled individually for 45 days in low density polypropylene.

Silage bags were opened 45 days later and representative sample from each silage bag was dried (60 °C) for dry matter (DM) determination. The finely ground samples of silage were analyzed for DM, crude protein (CP), total ash and ammonia N (AOAC 2007), cellulose (Crampton and Maynard 1938) and other cell wall constituents (Robertson and Van Soest 1981). Fresh silage samples were analyzed for *p*H, lactic acid (Barker and Summerson 1941). The parameters DMI, DDM, TDN, RFV, RFQ and NE_L were worked out from the equations adapted from Schroeder (2004).

Dry Matter Intake {DMI (% BW)} = 120 / (% NDF); Digestible Dry Matter (DDM) = 88.9 - (0.779 × % ADF); Total Digestible Nutrients (TDN) = 87.84- (0.79× % ADF); Relative Feed Value (RFV) = (% DDM × % DMI) / 1.29; Relative Feed Quality (RFQ) = (TDN × intake) /(16.8+39.2); Net Energy Lactation {NE_L (Mcal/kg)} = 0.0245×TDN – 0.1

The data of physical parameters, yield, chemical composition and nutritional evaluation were analysed by using analysis of variance (Snedecor and Cochran 1994) with SPSS (2012) version 16.0 and the means were tested for the significant difference by using Tukey's b test.

RESULTS AND DISCUSSION

Pre-harvest observations, green fodder yield and economics of cultivation: Maize hybrid DKC 9108 recorded significantly more (P<0.05) plant height at time of harvest as compared to hybrid PMH 10 and composite J1006 (Table 1). Plant height of cultivar J1006 was also significantly higher than PMH 10. Plant height variation between different maize cultivar might be due to their varied genetic makeup (Chaudhary *et al*. 2016). Significantly higher number of leaves per plant were recorded in DKC 9108 (13.67) followed by PMH 10 (12.33) and J1006 (11.0). Number of cobs per plant was numerically higher under PMH 10 as compared to DKC 9108 and J1006. Plant fresh weight was recorded significantly higher under hybrid PMH 10 which was at par with DKC 9108 and significantly higher than cultivar J1006. Green fodder yield (q/ha) and factor productivity (q/ha/day) was also higher under hybrid PMH 10 and found at par with hybrid DKC 9108 and further significantly higher than J1006. Although the plant height and number of leaves per plant were significantly higher under DKC 9108 but hybrid PMH 10 recorded numerically higher number of cobs per plant which resulted in higher plant fresh weight and ultimately leading to higher green fodder yield. Brar *et al.* (2019b) also reported significantly higher green fodder yield of a maize hybrid grown for silage making due to significantly higher number of cobs per plant as compared to other cultivars. Gupta *et al.* (2004) reported lower dry matter content under variety J1006 due to thin stems instead of its tall plants and broad leaves.

Table 1 Physical parameters, green fodder yield and economics of cultivation

Parameter	Maize cultivars		
	J 1006	PMH 10	DKC 9108
Plant height at harvest (cm)*	252 ± 1.67^{b}	232 ± 6.01^{c}	277 ± 4.04^{a}
No. of leaves per plant*	11.00 ± 0.00^{c}	12.33 ± 0.33^{b}	13.67 ± 0.33^{a}
No. of cobs per plant	1.0 ± 0.00	1.5 ± 0.29	1.0 ± 0.00
Plant fresh weight at harvest*	0.765 ± 0.04^{b}	1.023 ± 0.09^{a}	0.963 ± 0.05^{ab}
Green fodder yield (q/ha)*	580 ± 15.28^{b}	795 ± 20.21^{a}	745 ± 25.66^{a}
Factor productivity (q/ha/day)*	6.83 ± 0.18^{b}	9.33 ± 0.24^{a}	8.77 ± 0.30^{a}
Gross return (₹/ha)*	104400 ± 2750^{b}	143100 ± 3637^{a}	134100 ± 4618^{a}
Net returns (₹/ha)*	49657 ± 2750^{b}	85495 ± 3637^{a}	73017 ± 4618^{a}
BC ratio*	1.90 ± 0.06^{c}	2.50 ± 0.06^{a}	2.20 ± 0.06^{b}
Economic productivity (₹/ha/day)*	584 ± 32.35^{b}	1006 ± 42.79^{a}	859 ± 54.33^{a}

Cost of cultivation: J 1006- ₹ 54743/ha, PMH 10- ₹ 57605/ha, DKC 9108-₹ 61083/ha. Figures with different superscripts in a row differ significantly, *P<0.05.

Data regarding economics of cultivation (Table 1) shows that highest Net return and Economic productivity was recorded for hybrid PMH 10 which was at par with DKC 9108 and significantly higher than J1006, while PMH 10 recorded significantly higher BC ratio than DKC 9108 and J1006. Significantly higher net return under maize hybrid in comparison with composite J1006 was also recorded by Brar *et al*. (2016).

Evaluation of silage prepared from different maize cultivars

Fermentation characteristics: Quality of silage was evaluated with respect to pH, lactic acid and ammonia-N (Table 2). Silage pH and lactic acid are the indicative parameters of a good ensilage process. In this study, silage of maize hybrid PMH 10 recorded minimum value of pH which was at par with silage of hybrid DKC 9108 and significantly lower than J1006. The pH of silages prepared from PMH 10 and DKC 9108 were within the range of good quality silage as described by Mc Donald *et al.* (1991), while silage prepared from J1006 showed pH slightly higher than the optimum range. When dry matter is low (<35%), pH values of well preserved silages are within range of 3.5-4.2 was reported by Kaiser and Piltz (2004). Silage of hybrid PMH 10 also recorded lactic acid (% DM) 8.30 % which was significantly higher than the silages prepared from DKC 9108 and J1006. A low pH is an indication of good lactic acid bacteria fermentation that resulted in the optimum production of lactic acid to inhibit the growth of unwanted microorganisms such as clostridia and enterobacteria.

Production of ammonia N (% of total N), which indicates the breakdown of protein during silage making, was recorded significantly lower in silage prepared from PMH 10 and DKC 9108 as compared to J1006. All silage samples recorded excellent in quality with respect to ammonia-N as described by Wilkinson (1990).

Nutritive value: The dry matter content of silage from tested cultivars varied from 19.53–22.47% (Table 2). Silages of Hybrid DKC 9108 and PMH 10 recorded significantly higher dry matter content than silage of J1006. Lower dry matter percentage in silage of cultivar J1006 as compared to other genotypes of maize was also reported by Chaudhary *et al*. (2016).

The proximate analysis (Table 2) revealed that the

Table 2 Quality of silage prepared from different maize cultivars

Parameter	Maize cultivars		
	J 1006	PMH 10	DKC 9108
Fermentation characteristics			
*p*H*	4.38 ± 0.02[a]	4.10 ± 0.04[b]	4.29 ± 0.08[ab]
Lactic acid (% DM)*	6.50 ± 0.01[c]	8.30 ± 0.17[a]	7.17 ± 0.03[b]
Ammonia N (% Total N)*	2.30 ± 0.01[a]	1.97 ± 0.04[b]	1.97 ± 0.04[b]
Nutrient composition (% DM)			
Dry matter*	21.90 ± 0.12[a]	19.53 ± 0.30[b]	22.47 ± 0.38[a]
Crude protein*	5.55 ± 0.03[c]	8.44 ± 0.10[a]	8.15 ± 0.04[b]
Ether extract	1.77 ± 0.14	2.07 ± 0.03	2.07 ± 0.03
NDF*	73.60 ± 0.07[a]	66.40 ± 0.12[b]	65.50 ± 0.17[c]
ADF*	36.90 ± 0.12[a]	35.77 ± 0.14[b]	35.97 ± 0.20[b]
ADL*	5.10 ± 0.06[a]	4.10 ± 0.06[b]	5.27 ± 0.14[a]
Cellulose*	34.40 ± 0.06[a]	30.70 ± 0.29[b]	30.80 ± 0.06[b]
Hemicellulose*	36.70 ± 0.12[a]	30.63 ± 0.03[b]	29.53 ± 0.03[c]
Ash*	5.20 ± 0.04[c]	6.70 ± 0.03[b]	7.50 ± 0.04[a]
OM*	94.80 ± 0.04[a]	93.30 ± 0.03[b]	92.53 ± 0.04[c]
Feed value			
DMI (%BW)	1.63 ± 0.00[c]	1.81 ± 0.00[b]	1.83 ± 0.00[a]
DDM, %*	60.15 ± 0.09[b]	61.05 ± 0.11[a]	60.90 ± 0.16[a]
TDN, %*	62.01 ± 0.08[b]	62.82 ± 0.10[a]	62.68 ± 0.14[a]
RFV*	76.03 ± 0.11[b]	85.53 ± 0.31[a]	86.49 ± 0.45[a]
RFQ*	1.81 ± 0.00[b]	2.03 ± 0.01[a]	2.05 ± 0.01[a]
NE_L (M cal/kg)*	1.40 ± 0.00[b]	1.42 ± 0.00[a]	1.42 ± 0.00[a]

NDF- Neutral detergent fiber, ADF- Acid detergent fiber, ADL- Acid detergent lignin, OM- Organic matter, DMI-Dry matter intake, DDM-Digestible dry matter, TDN-Total digestible nutrient, RFV- Relative feed value, RFQ- Relative feed quality, NE_L -Net energy lactation; Figures with different superscripts in a row differ significantly, *P<0.05.

crude protein content in silages of different cultivars varied (P>0.05) from 5.55 % (J1006) to 8.15% (DKC 9108) and 8.44 (PMH 10). As at the time of harvesting, cultivar J1006 was at blister stage with less developed grains than hybrids PMH 10 and DKC 9108 (were at milk to dough stage), thus resulting lower value of crude protein content in silage prepared from J1006. The values of ether extract recorded 1.77 in silage of J1006 as compared to 2.07 in silage of both PMH 10 and DKC 9108, however values remained statistically comparable with each other. Comparable ether extracts content and minerals among different maize hybrids were reported by Pereira *et al.* (2007), Araujo *et al.* (2012) and Kumar *et al*. (2019). The NDF content of silage (Table 2), an indicator of dry matter intake, varied from 65.50% (DKC 9108) to 73.60% (J1006) on DM basis (Chaudhary *et al.* 2016, Brar *et al*. 2019a). The ADF content, an indicator of digestibility, was observed significantly lowest in silage prepared from PMH 10 (35.77%) and DKC 9108 (35.97%) hybrids as compared to J1006 (36.90%) (Table 2). In present study, ADL content varied from 4.10–5.27% in silage (Table 2). Silage of maize hybrid PMH 10 recorded significantly lower value of ADL as compared to silage of DKC 9108 and J1006. The results are in line with Chaudhary *et al.* (2016), Brar *et al.* (2019a) and Hundal *et al.* (2019). Cellulose and hemicellulose contents in silage of PMH 10 and DKC 9108 hybrids were significantly lower than silage of J1006. Ash content was significantly higher in silage of DKC 9108 followed by PMH 10 and J1006.

Feed values: Data (Table 2) showed that silage prepared from maize hybrid PMH 10 and DKC 9108 were statistically similar with respect to DDM, TDN, RFV, RFQ and NE_L, however all these parameters were significantly higher than cultivar J1006. Dry matter intake values varied between 1.63% in silage made from cultivar J1006 to 1.83% from silage of DKC 9108. The energy content of silage which is expressed in terms of TDN (%) and NE_L (Mcal/kg) was significantly higher in silage of PMH 10 and DKC 9108 because of significant lower ADF in their silages as compared to silage of J1006. High TDN and NE_L content of silage reflected optimum energy density and with increase in lignin content in the forages, their energy content get decreased (Hundal *et al*. 2020). RFV and RFQ of silage of DKC 9108 and PMH 10 were statistically same and significantly higher than cultivar J1006. Higher RFV and RFQ values are the confirmation to good quality silage.

From above discussion, it is concluded that under intensive cropping system, PMH 10 and DKC 9108 hybrids of maize are the best suitable for cultivation during spring season for quality silage production.

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