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Evaluation of maize cultivars for forage yield, silage quality traits and nutrient uptake in agro-climatic conditions of central Gujarat, India

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Abstract
To evaluate fodder productivity, silage quality and nutrients uptake potential in 11 maize cultivars, a study was conducted during two seasons *i.e.* *Kharif* 2016 and *Zaid* 2017. Study indicated superiority of fodder composite African Tall for green fodder yield (35.19 t ha^{-1}) due to significantly higher plant height (265.13 cm), stem-girth (16.58 cm), number of leaves $plant^{-1}$ (13.87) and nitrogen uptake (145.34 kg ha^{-1}). Four cultivars namely African Tall, Pratap Makka Chari-6, P-3502 and Pratap Hybrid Maize-3 produced more than 30 t ha^{-1} green fodder that was higher than local check, Gujarat Anand Yellow Maize Hybrid-1. P-3502 recorded highest crude protein yield (8.14 t ha^{-1}) and Mg content (0.56%), while Rajshri was found to be superior in terms of brix (8.83%) and sulphur (0.13%) contents. Phosphorus content (%) was found highest in J-1006 (0.29) and calcium uptake was recorded highest in Pratap Makka Chari-6 (28.60 kg ha^{-1}). Pratap Hybrid Maize-3 recorded higher P_2O_5 uptake (51.16 kg ha^{-1}), K_2O uptake (79.45 kg ha^{-1}) and copper content (63.71ppm). In maize silage, mean pH, dry matter, crude protein, ether extract, crude fibre, silica content varied between 3.78 to 4.27, 24.77 to 27.57 %, 8.71 to 10.69%, 1.02 to 1.59%, 28.86 to 31.66% and 3.27 to 4.40%, respectively. African Tall, Pratap Makka Chari-6, Pratap Hybrid Maize-3 and P-3502 cultivars were found to be most suitable for silage making.

Keywords: Fodder yield, Maize cultivar, Nutrients uptake, Proximate, Silage quality

Introduction

Maize (*Zea mays* L.) is being grown in tropics, sub-tropics and temperate regions up to 50^0 N and S from the equator to more than 3000 m above sea level (Patel *et al*., 2014). In India, maize is an important dual purpose cereal crop which is cultivated by farmers for food, feed and fodder purposes. Maize area and production is growing due to diverse uses and increase in demand from poultry, starch industries and application in diversified industries such as alcoholic beverages, bio-fuel, processed food and corn oil (FICCI, 2014). It is grown in almost all agro-ecological regions, contributing about 22 million tonnes of grain production from about 9 million hectares of land (Kumar *et al*., 2014). In India, maize is grown exclusively as a green fodder crop in 0.9 million hectare land (Pandey and Roy, 2011). Maize gives more nutritious fodder yields with higher net return and benefit: cost ratio with the uniform series of maize + cowpea intercropping system (Saad *et al.,* 2016). Maize is an ideal crop for silage as its fodder is rich in water soluble carbohydrates (WSC) and consists of low buffering capacity, which also makes it the easiest crop to ensile.

Maize silage is important forage and major energy source in dairy cattle rations both in Europe and North America (Ettle and Schwarz, 2003). Presently there is a chronic shortage of green fodder in the country and therefore, silage may play a critical role in filling the wide gap in availability and requirement of quality green forages for animals. Due to efforts of public sector institutes, private sector companies and from implementation of centrally funded dairy development programme like National Dairy Plan I (NDP I) during 2012-20, have created clear understanding about ensiling technology among farmers leading to successful silage production for lean period in large quantities. Farmers in many states like Punjab, Gujarat, Andhra Pradesh, Karnataka and Maharashtra farmers have adopted innovative methods of silage making to meet out fodder requirements of milch animals particularly during summer season. There are several factors which affect quantity and quality of silage production but selection of maize cultivar (composite or hybrid) for cultivation is the most important factor due to genetics.

Different types of maize cultivars cultivated for fodder, grain and vegetable purpose, developed by public sector institutes and private seed companies, are being used by farmers for silage making (ensiling) purpose. Several researchers have reported that the effects of hybrids on maize dry matter (DM) yield and quality characteristics are variable (Pinter *et al.*, 1994). Maize DM yield and its nutritive value are influenced by numerous interactions including genetic factors (Graybill *et al.,* 1991). Hybrid selection is a key to improve forage quality for optimum animal output (Widdicombe and Thelen, 2002). The information regarding the performance of different kinds of maize cultivars for fodder yield, nutrient content and silage quality under Central Gujarat condition is, however, limited. Therefore, the present study was undertaken with the objectives to find out the most suitable maize cultivars for green fodder production and ensiling purpose.

Materials and Methods

Crop growing conditions: A field experiment was undertaken during two seasons *i.e. Kharif* 2016 and *Zaid* 2017 at fodder demonstration unit (FDU) of National Dairy Development Board, Anand (India) situated at 22° 33' N latitude and 72° 57' E longitude at an elevation of 41 meter above mean sea level. The soil of the experimental site was loamy in texture with EC (0.19), pH (7.71), total nitrogen (899.63 kg ha^{-1}), available P_2O_5 (12.83 kg ha^{-1}) and available K_2O (272.42 kg ha^{-1}). The soil contained DTPA-extractable Fe (5.81 ppm), Mn (4.33 ppm), Zn (1.83 ppm), available S (3.08 ppm) and Cu (1.37 ppm).The crop was sown with a seed rate of 20 kg ha^{-1} at row spacing of 50 cm x 20 cm on 2nd July, 2016 and on 24th February, 2017. All the recommended agronomic practices were followed and each plot was fertilized with 150 kg nitrogen (N), 60 kg phosphorus (P_2O_5) and 40 kg potash (K_2O) per ha. One-third dose of N and full dose of P_2O_5 and K_2O nutrients were given by application of ammonium sulphate, single super phosphate and murate of potash as basal. To control weeds, tank spray of atrazine was applied as pre-emergence @ 0.75 kg a.i. ha^{-1} followed by hand weeding and earthing up operation at 25-30 days after sowing. Remaining N was top dressed in two equal doses at 35 & 55 days after sowing. The crop was harvested at 80 days after sowing for estimation of growth, fodder yield, ensiling and quality.

Experimental design: The experiment was laid out in randomized block design (RBD) with 3 replications consisting of 11 treatments of maize cultivars (4 composites and 7 hybrids). Maize composites were Narmada Moti (NM), J-1006, Pratap Makka Chari-6 (PMC-6) and African Tall (AT). Maize hybrids were P-3502, P-31Y45, Rajshri, Pratap Hybrid Maize-3 (PHM-3), Gujarat Anand Yellow Maize Hybrid-1 (GAYMH-1), Gujarat Anand White Maize Hybrid-2 (GAWMH-2) and High Quality Protein Maize-1 (HQPM-1). In this study, AT and GAYMH-1 were treated as a national check (NC) and local check (LC) cultivar, respectively for evaluation.Treatment plot, total size was 5.0 x 4.0 metre at sowing and net size of 3.0 x 3.0 metre at harvesting stage.

Sampling and ensiling: At harvest, for the growth and developmental studies, six plants were selected at random from the selected row of each net plot. Representative plant samples were collected and biomass yield data was recorded. Plot-wise green forage yield was multiplied by respective dry matter percentage to get dry weight in kg per plot and was expressed in t ha^{-1}. Green fodder was chopped to 1-2 cm length for ensiling (silage making). Chopped fodder was tightly filled, compacted and sealed manually in air tight plastic containers of 8 kg capacity for ensiling. After 45 days, sealed containers were opened and representative silage samples were taken for quality analysis. Silage samples (500 g) were oven dried at 75°C for 48 hours to achieve constant weight for dry matter content and thereafter, fine grinded (1 mm) for laboratory analysis.

Chemical and statistical analysis: Amount of nitrogen (N) and crude protein content was estimated by using ISO 5983-2 (2009). Proximate analysis of silage samples was carried out following the standard laboratory procedures recommended by AOAC (2012). Mineral content was determined according to Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES), Perkin Elmer, OPTIMA-8000. The total soluble solids (TSS°) brix was estimated by placing few drops of stem juice on the surface of the erma hand refractometer. Two season's data for growth, yield, proximate and nutrients content was pooled and statistically analyzed by ANOVA (analysis of variance) following Sheron *et al.* (1998). Treatments means were compared at 5% level of LSD (least significant difference).

Results and Discussion

Fodder yield

Growth parameters: Pooled analysis indicated significant differences for growth parameters in maize cultivars (composites and hybrids; Table 1). Fodder type composites AT (265.13 cm) and PMC-6 (259.13 cm) statistically at par amongst themselves recorded significantly higher plant height in comparison to rest of the maize cultivars. However, among maize hybrids, P-3502 at par with PHM-3 recorded significantly higher plant height in comparison to other hybrids. Average plant height was observed more in maize composites (240.67

cm) than maize hybrids (204.77 cm). Average stem girth was also observed higher in maize composites (15.89 cm) in comparison to maize hybrids (14.86 cm). National check composite AT (16.58 cm) statistically at par with two fodder composites J-1006 (16.21 cm) and PMC-6 (15.59 cm) recorded significantly higher stem girth than remaining maize cultivars. Similar findings were reported earlier by Kumar *et al.* (2016) for fodder composites AT and J-1006. Significantly higher number of leaves per plant were recorded in AT (13.87) in comparison to rest of maize cultivars (Table 1).

Yield: Statistical differences were found to be significant for green fodder and crude protein yields between maize cultivars (Table 1). National check fodder maize composite AT (35.19 t ha^{-1}) statistically at par with PMC-6 (34.91 t ha^{-1}), P-3502 (32.20 t ha^{-1}) and PHM-3 (30.93 t ha^{-1}) recorded significantly higher green fodder yield (GFY) than remaining cultivars. Among hybrid maize, P-3502 recorded maximum GFY but significant differences were found only in comparison to GAWMH-2 (23.98 t ha^{-1}) and NM (25.46 t ha^{-1}). Among all maize cultivars, AT was found superior in terms of plant height, stem girth and number of leaves per plant which might have contributed to its highest green fodder yield. Shanti *et al.* (2012) had also reported highest green fodder yield in AT grown for fodder purpose. Higher green fodder yield in AT in comparison to J-1006 was also reported by Bhagat *et al.* (2017). Kumar and Singh (2004) reported that the dry matter yield per plant was significantly and positively associated with green fodder yield and growth parameters such as plant height, number of leaves per plant and stem girth. Statistical differences for dry matter yield (DMY) were found non-significant but more than 8 t ha^{-1} DMY was recorded in PMC-6, AT and P-3502. Overall among maize cultivars, mean DMY varied from 6.54 to 8.91 t ha^{-1}. Our findings were in line with Kumar *et al.* (2016). Maize cultivars P-3502, AT and PMC-6 at par amongst themselves produced significantly highest crude protein yield (CPY) between 0.82 to 0.84 t ha^{-1} in comparison to NM, P-31Y45, GAWMH-2 and local check GAYMH-1 (Table 1).

Fodder quality

Chemical composition: The chemical composition of maize cultivars was recorded (Table 2). Non-significant differences were observed among maize cultivars for quality parameters in silage *viz.*, dry matter (DM), crude protein (CP), ether extract (EE), crude fibre (CF) and silica content. Among maize cultivars mean DM, CP, EE, CF and silica content (%) in silage ranged between 24.77 to 27.57, 8.71 to 10.69, 1.02 to 1.59, 28.86 to 31.66 and 3.27 to 4.40, respectively. Non-significant differences in quality parameters among 11 maize cultivars might be due to similar date of harvest for ensiling. Similar findings were observed by Kumar *et al.* (2017) for fodder quality

Table 1. Influence of cultivars on growth and yield of maize crop (pooled means of two seasons)

Treatment	Plant height	Stem girth	Number of leaves plant^{-1}	Green fodder yield (GFY)	Dry matter yield (DMY)	Crude protein yield (CPY)
Composites	(cm)				(t ha^{-1})	
Narmada Moti (NM)	216.28	15.17	11.70	25.46	6.90	0.57
J-1006	222.12	16.21	12.27	28.66	7.22	0.67
Pratap Makka Chari (PMC-6)	259.13	15.59	12.50	34.91	8.91	0.82
African Tall (AT) NC	265.13	16.58	13.87	35.19	8.61	0.83
Average	240.67	15.89	12.59	31.06	7.91	0.72
Hybrids						
P-3502	222.78	15.06	12.18	32.20	8.14	0.84
P-31Y45	202.78	15.03	11.40	29.63	7.95	0.65
RAJSHRI	183.96	15.38	11.70	28.87	7.52	0.74
Pratap Hybrid Maize-3 (PHM-3)	220.28	14.22	12.30	30.93	7.84	0.73
Gujarat Anand Yellow Maize Hybrid-1 (GAYMH-1) LC	203.95	14.31	11.66	29.05	7.42	0.60
Gujarat Anand White Maize Hybrid-2 (GAWMH-2)	208.68	14.67	10.90	23.98	6.54	0.54
High Quality Protein Maize-1 (HQPM-1)	190.98	15.31	11.47	29.72	7.65	0.71
Average	204.77	14.85	11.66	29.20	7.58	0.69
SEm$\pm$	3.92	0.40	0.28	1.74	0.59	0.06
CD ($P \leq 0.05$)	11.57	1.18	0.84	5.15	NS	0.17

NC: National check; LC: Local check

attributes. Brar *et al*. (2019) also reported non-significant differences among the three maize hybrids *viz*., P-1844, DOW-2244 and P-31Y45 with respect to dry matter and crude protein (%) during field trial in Punjab. Datt *et al.* (2006) observed the non-significant variations in crude protein, ether extract, crude fibre, total ash and nitrogen free content in ten different cultivars of maize including some cultivars and their crosses.

Crude protein: More than 10% crude protein (CP) in maize silage was observed in cultivars Rajshri (10.69%), AT (10.62%) and P-3502 (10.57%). Shanti *et al.* (2013) also observed more than 10% CP in many maize cultivars including AT (10.06%) at harvest of I^{st} cob. Katoch and Kumar (2014) reported CP in maize cultivars for fodder upto 11.96%. In quality protein maize (QPM) hybrid HQPM-1, CP content was not recorded significantly higher than other cultivars. Similar to present findings, Vaswani *et al.* (2016) also reported CP concentration ranged from 6.19 to 8.39% in fodder of maize cultivars at post cob stage and found that High Quality Protein Maize (HQPM) cultivars did not show higher content of CP than normal maize. According to Akumoa-Boateng (2002) and Nuss and Tanumihardjo (2011) CP content in QPM was also not higher than that of normal maize, however, it was better in terms of amino acids composition.

Brix: Degrees Brix (°brix) is a biochemical maturity index that measures the total soluble solids (TSS%) dissolved in a substance and it is influenced by the sugar level content and the rapid change of sugar to starch at maturity in maize (Mubanga *et al.,* 2018). TSS or Brix represents the percentage by mass of total soluble solids of a pure aqueous sucrose solution (Pereira *et al*., 2013). Magwaza and Opara (2015) reported that 'Brix' technically refers only to the sugar content (sucrose, glucose and fructose) and sugar alcohols (sorbitol and manitol) that constitute the majority (approximately 85%) of total soluble solids in fruit juices. Balsom and Lunch (2008) reported that quality silage and hay generally should have high fruit sugar content, low nitrate levels and high digestibility values. Thus sugar content is one of a few important factors affecting feed quality. Hence, higher °brix may indicated the availability of total soluble sugars (sucrose, glucose and fructose) in green fodder for rapid fermentation needed during ensiling process. In this trial, TSS content in stem juice of maize cultivars significantly varied from 6.19 to 8.83°brix (Table 2). Maize hybrid Rajshri (8.83°brix) statistically at par with local check hybrid GAYMH-1 (8.08 °brix) and P-31Y45 (7.82 °brix) recorded significantly higher TSS content over remaining maize cultivars. Among maize composites, highest TSS was recorded for J-1006 (7.54 °brix) followed by AT (7.44 °brix).

Table 2. Influence of cultivars on chemical composition of maize silage (pooled means of two seasons)

Treatment	Dry matter (DM)	Brix (Total soluble solids)	Crude protein (CP)	Ether extract (EE)	Crude fibre CF)	Silica	pH (As such basis)
Composites				%			
Narmada Moti (NM)	26.80	7.02	9.12	1.46	31.28	3.43	4.05
J-1006	25.16	7.54	8.97	1.59	30.94	3.23	4.05
Pratap Makka Chari (PMC-6)	25.77	7.15	9.88	1.15	29.56	4.09	3.78
African Tall (AT) NC	24.77	7.44	10.62	1.02	29.24	3.67	4.27
Average	25.63	7.29	9.65	1.31	30.26	3.61	4.04
Hybrids							
P-3502	25.48	6.19	10.57	1.08	30.02	3.92	4.11
P-31Y45	26.83	7.82	8.71	1.13	28.90	4.34	3.95
RAJSHRI	25.81	8.83	10.69	1.10	30.09	4.15	4.21
Pratap Hybrid Maize-3 (PHM-3)	25.61	6.43	9.18	1.37	31.66	4.00	3.98
Gujarat Anand Yellow Maize Hybrid-1 (GAYMH-1) LC	26.30	8.08	9.17	1.35	29.67	4.40	3.91
Gujarat Anand White Maize Hybrid-2 (GAWMH-2)	27.57	6.69	9.72	1.34	31.29	3.74	3.89
High Quality Protein Maize-1 (HQPM-1)	26.00	6.54	9.51	1.41	28.86	4.27	3.86
Average	26.23	7.23	9.65	1.25	30.07	4.12	3.99
SEm±	1.10	0.47	0.65	0.18	1.68	0.55	0.07
CD ($P \leq 0.05$)	NS	1.37	NS	NS	NS	NS	0.20

NC: National check; LC: Local check

pH: pH of maize silage differed significantly due to cultivars effect (Table 2). Lower pH in silage indicated higher content of lactic acid as this acid is stronger than the other acids in silage (acetic, propionic and butyric), and therefore, is usually responsible for most of the drop in silage pH as reported by Kung and Shaver (2001). Significantly lower pH was recorded in composite PMC-6 (3.78) but statistically at par with hybrids HQPM-1 (3.86), GAWMH-2 (3.89), GAYMH-1 (3.91), P-31Y45 (3.95) and PHM-3 (3.98). Similar findings were observed by Chaudhary *et al.* (2016) who reported pH less than 4.0 in silage samples of five maize cultivars, indicating its excellent fermentation during preservation process. Jalč *et al. (*2010) reported that active acidity (pH) in maize silage ranged from 3.52 to 3.80 during 2009 and from 3.58 to 4.14 during 2010 trials, respectively. Vranić *et al.* (2004) analyzed 96 maize silages and recorded average value of pH 3.7 in samples. Kung and Shaver (2001) had reported pH range of low moisture maize silage from 3.7 to 4.2 and high moisture maize between 4.0-4.5. Brar *et al.* (2019) reported that pH in 21 silage samples varied from 3.6 to 4.3.

Nutrient content

Macronutrients: Statistical differences were significant among cultivars for phosphorus (P), magnesium (Mg) and sulphur (S) content and differences were non-significant for nitrogen (N) and calcium (Ca) contents (Table 3). Maize composite J-1006 (0.29%) statistically at par with hybrids PHM-3 and HQPM-1 recorded highest P than remaining cultivars. Lowest P was recorded for NM (0.20%). K was found significantly higher in hybrid PHM-3 (0.85%) and lowest K (0.58%) was found in NM and GAWMH-2 cultivars. Ca varied non-significantly from 0.21 to 0.33% among cultivars. Vaswani *et al.* (2016) reported that Ca and P (%) in different maize cultivars varied from 0.64 to 1.11 and 0.03 to 0.07, respectively. Highest Mg was observed in hybrid P-3502 (0.56%), whereas lowest Mg was recorded for PHM-3 (0.44%) and GAYMH-1 (0.44%). S content significantly varied amongst maize cultivars and highest value was recorded in hybrids Rajshri, GAYMH-1 and HQPM-1 (0.13%), while lowest in composite NM (0.10%).

Micronutrients: Significant differences were observed amongst maize cultivars for copper (Cu) and non-significant differences for zinc (Zn), manganese (Mn) and iron (Fe) contents (Table 3). Hybrid PHM-3 (8.16 ppm) statistically at par with Rajshri (7.03 ppm) and GAYMH-1 (6.93 ppm) recorded significantly higher Cu than remaining maize cultivars. Zn, Mn and Fe contents in maize cultivars were recorded between 20.00 to 28.90 ppm, 38.56 to 57.89 ppm, and 725.00 to 1063.08 ppm, respectively. In this study, micronutrients concentration in maize cultivars silage on dry matter basis was well above the critical level. Vaswani *et al.* (2016) observed

Table 3. Influence of cultivars on nutrients content of maize silage (pooled means of two seasons)

Treatment	N	P	K	Ca	Mg	S	Zn	Cu	Mn	Fe
Composites				%				ppm		
Narmada Moti (NM)	1.46	0.20	0.58	0.25	0.49	0.10	20.84	5.42	38.56	800.17
J-1006	1.43	0.29	0.65	0.26	0.48	0.12	28.90	6.70	48.33	729.70
Pratap Makka Chari (PMC-6)	1.58	0.24	0.68	0.33	0.52	0.12	26.46	6.69	51.69	725.00
African Tall (AT) NC	1.70	0.25	0.72	0.25	0.49	0.12	20.00	6.26	43.69	586.33
Average	1.54	0.25	0.66	0.27	0.50	0.12	24.05	6.27	45.57	710.30
Hybrids										
P-3502	1.69	0.22	0.61	0.29	0.56	0.12	22.37	5.76	52.28	825.21
P-31Y45	1.39	0.23	0.63	0.21	0.50	0.11	20.00	6.05	41.71	893.49
RAJSHRI	1.71	0.26	0.61	0.28	0.47	0.13	23.81	7.03	53.86	820.02
Pratap Hybrid Maize-3 (PHM-3)	1.47	0.28	0.85	0.27	0.44	0.11	25.18	8.16	57.89	999.33
Gujarat Anand Yellow Maize Hybrid-1 (GAYMH-1) LC	1.47	0.22	0.70	0.25	0.44	0.13	20.94	6.93	48.35	840.83
Gujarat Anand White Maize Hybrid-2 (GAWMH-2)	1.56	0.21	0.58	0.25	0.47	0.11	20.00	6.33	40.67	878.85
High Quality Protein Maize-1 (HQPM-1)	1.52	0.26	0.71	0.26	0.49	0.13	21.11	6.54	48.71	1063.08
Average	1.54	0.24	0.67	0.26	0.48	0.12	21.92	6.69	49.07	902.97
SEm$\pm$	0.10	0.01	0.04	0.02	0.02	0.01	2.36	0.44	4.21	89.52
CD ($P \leq 0.05$)	NS	0.03	0.12	NS	0.07	0.01	NS	1.31	NS	NS

NC: National check; LC: Local check

Cu, Zn, Mn and Fe concentration in 10 maize cultivars silage in appreciable quantities and ranged between 7.12 to 8.76, 27.12 to 58.20, 25.92 to 72.54 and 404.28 to 678.60 ppm, respectively. Tandon (2009) reported critical micronutrient level in plant dry matter varied between 3 to 10, 15 to 20, 10 to 30 and 25 to 80 ppm for Cu, Zn, Mn and Fe, respectively.

Nutrient uptake

Macronutrients: The pooled data revealed significant differences among cultivars for macronutrients uptake *viz.*, N, P_2O_5, K_2O, Ca and S (Table 4). Highest N uptake was recorded for national check composite AT (145.34 kg ha^{-1}), that contributed to its highest GFY as nitrogen imparts towards higher vegetative growth. NM recorded lowest N uptake (98.40 kg ha^{-1}), that was also true as its GFY was lowest. Similarly P_2O_5 uptake also varied significantly from 30.46 to 51.16 kg ha^{-1}, being maximum in PHM-3 (51.16 kg ha^{-1}). Amongst maize cultivars, K_2O uptake was significantly higher in PHM-3 (79.45 kg ha^{-1}) but at par with PMC-6, AT and HQPM-1. Jain (1987) reported that maize crop producing 5.2 ton grain ha^{-1} absorbed 164 kg N, 35 kg P_2O_5 and 128 kg K_2O per ha basis from soil. Singh *et al*. (2015) reported that total macronutrient uptake by maize crop fertilized with 150 kg N + 60 P_2O_5 was 119.2, 58.43 and 105.65 kg ha^{-1} for N, P_2O_5 and K_2O, respectively. Ca uptake was recorded significantly higher in PMC-6 (28.60 kg ha^{-1}) in comparison to remaining cultivars. S uptake (10.88 kg ha^{-1}) was also recorded significantly higher in PMC-6 but statically at par with AT, P-3502, Rajshri, GAYMH-1 and HQPM-1. Lowest Ca (16.58 kg ha^{-1}) and S (7.07 kg ha^{-1}) uptakes were recorded in composite NM. Mg uptakes varied non-significantly between 30.85 to 45.66 kg ha^{-1} amongst maize cultivars. Jain and Sharma (1993) reported uptakes of Ca- 27 kg ha^{-1}, Mg- 39 kg ha^{-1}and S- 19 kg ha^{-1} in maize crops. Under a long-term field experiment in a black clay soil at Jabalpur, maize fodder crop producing 5.75 t ha^{-1} DM recorded an uptake of 96 kg N, 34.4 kg P_2O_5, 210.6 kg K_2O, 41 kg Ca, 22 kg Mg and 9.4 kg S (Nambiar, 1994).

Micronutrients: Among maize cultivars, non-significant differences were recorded for micronutrient uptakes (Table 4). However, Cu, Zn, Mn and Fe uptake values were ranged between 36.72 to 63.71, 130.70 to 237.80, 265.57 to 458.56 and 5241.51 to 8145.58 g ha^{-1}, respectively in maize cultivars. Tandon (2009) observed average uptakes of 130, 130, 320 and 1200 g ha^{-1} for micro-nutrients Cu, Zn, Mn, and Fe, respectively in maize crops.

Table 4. Influence of cultivars on nutrients uptake of maize crop (pooled means of two seasons)

Treatment	Macronutrient uptake (kg ha^{-1})						Micronutrient uptake (g ha^{-1})			
Composites	**N**	**P_2O_5**	**K_2O**	**Ca**	**Mg**	**S**	**Zn**	**Cu**	**Mn**	**Fe**
Narmada Moti (NM)	98.40	30.46	49.04	16.58	33.10	7.07	143.35	36.72	265.71	5631.06
J-1006	103.87	47.45	55.27	18.80	34.80	8.83	214.47	48.89	355.15	5241.51
Pratap Makka Chari (PMC-6)	137.91	49.73	73.80	28.60	45.66	10.88	237.80	59.27	458.56	6577.63
African Tall (AT) NC	145.34	48.51	73.02	21.48	41.60	10.10	172.20	53.39	378.33	5314.30
Average	121.38	44.04	62.78	21.37	38.79	9.22	191.96	49.57	364.44	5691.13
Hybrids										
P-3502	138.19	41.22	60.19	22.95	45.29	9.79	183.65	46.69	428.48	6718.59
P-31Y45	111.00	41.76	59.34	16.96	39.99	8.62	158.97	48.27	334.48	7139.88
RAJSHRI	125.57	45.24	54.57	20.77	34.74	9.70	179.35	53.34	415.66	6314.65
Pratap Hybrid Maize-3 (PHM-3)	114.47	51.16	79.45	20.99	34.27	8.57	196.00	63.71	452.13	7696.98
Gujarat Anand Yellow Maize Hybrid-1 (GAYMH-1) LC	107.85	37.21	61.93	18.60	32.86	9.25	155.15	51.49	359.69	6283.12
Gujarat Anand White Maize Hybrid-2 (GAWMH-2)	101.45	31.86	45.16	16.15	30.85	7.41	130.70	41.60	265.57	5659.14
High Quality Protein Maize-1 (HQPM-1)	116.53	46.17	65.07	19.76	37.20	9.94	161.52	50.04	372.99	8145.58
Average	116.44	42.09	60.82	19.45	36.46	9.04	166.48	50.73	375.57	6851.13
SEm$\pm$	8.80	3.84	5.10	1.82	3.41	0.69	25.52	5.43	47.41	805.86
CD ($P \leq 0.05$)	25.97	11.33	15.05	5.36	NS	2.03	NS	NS	NS	NS

NC: National check; LC: Local check

Conclusion

Two season's trial indicated superior genetic potential in maize cultivars for high productivity and quality forages required for ensiling at 80 days harvesting stage. Silage quality traits, macro and micro nutrient concentrations in silage of maize cultivars were also recorded at desirable level and within critical limits. Since, green fodder yields of greater than 30 t ha^{-1} were recorded in four cultivars AT, PMC-6, P-3502 and PHM-3 over local check GAYMH-1, therefore, these cultivars may be promoted for getting higher silage yields per ha basis in the agro-climatic conditions of central Gujarat.

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