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RESEARCH PAPER

Differential responses of yield and quality to organic manures in sweet corn [*Zea mays* (L.) *saccharata*]

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Abstract : The experiment has twenty four treatment combinations comprising of six main plots, organic manures mainly green leaf manure (GLM), enriched compost, FYM and vermicompost in combinations compared with RDF and FYM + RDF and four sub plots, liquid organic manures mainly bio-digester liquid manure, *Panchagavya* and cow-urine. The treatments comprised of application of 7.5 t FYM + RDF (100:50:25 N, P_2O_5, K_2O kg ha^{-1} + 10 kg $ZnSO_4$) (RPP) and (100:50:25 N, P_2O_5, K_2O kg ha^{-1} + 10 kg $ZnSO_4$) (RDF) alone exhibited significant effects on yield of sweet corn *viz.*, with husk and without husk cob weight per plant, fresh cob yield, fresh and dry grain weight per plant and quality parameters *viz.*, protein content, reducing and non-reducing sugar, total sugar, total soluble solids and total carbohydrates content in sweet corn kernels of sweet corn. Among the organic manurial combinations GLM + EC + VC (top dressing at GGS) recorded higher yield and quality of sweet corn with all liquid organic manures over basal applied vermicompost. Similarly, bio-digester and cow urine @ 10 per cent spray noticed higher yield and quality of sweet corn over control. Irrespective of organic manures, the dehydrogenase activity were significantly higher with GLM + FYM + VC (top dressing at GGS) and GLM + EC + VC (basal) equivalent to RDN over RPP and RDF.

Key Words : Sweet corn, Organic manures, Liquid organic manures, Fertilizer, Yield, Dehydrogenase activity, Quality

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INTRODUCTION

Sweet corn is peculiarly an American crop. It cannot be regarded as a staple food but it is consumed fresh as a confection. In sweet corn, the conversion of sugar into starch in the endosperm of the kernels does not proceed to completion as it does in starchy types of maize *viz.*, dent, flint and pop. Thus, the storage material in the endosperm is composed of sugars-glucose and sucrose and of intermediate polysaccharide products generally classified as dextrins. In Mexico and among the Indians of the upper Mississippi, sweet corn was the basis of pinole, a confection prepared by grinding the mature seeds. In Peru, kernels of sweet corn were parched to produce a favourite food, kamela. In that region, sweet corn also found a special niche in the preparation of the native beer, chinch to which by the virtue of its greater sugar content it imparted a higher alcoholic potency. Subsequently, it found a special niche in the United States, where it is consumed as a green corn or roasted ears or

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as canned and frozen corn. In India, the green ears of maize are consumed directly as roasted ears in and around cities. The demand for sweet corn in the amusement parks, theaters, circus and exhibitions is increasing with increasing urban population. Due to its increasing demand, there is an increasing tendency for commercial production of sweet corn.

MATERIAL AND METHODS

The present investigation was carried out in *Kharif* 2009-10, under Main Agricultural Research Station, Dharwad which comes under Northern Transitional Zone of Karnataka with an average annual rainfall of 750 mm. The sweet corn variety Madhuri was used. The seeds were hand dibbled at 60 × 30 cm spacing at optimum moisture conditions. The crop was raised under rainfed conditions. The trial comprised of 24 treatment combinations having six main plots, mainly four organic manurial combinations equivalent to recommended chemical fertilizer, one recommended dose of chemical fertilizer (RDF) and a recommended package of practice (RPP) (7.5 t FYM +RDF) with four sub plots having 3 liquid organic sprays and control were laid out in Split-Plot Design with three replications. Based on the nutrient content of organic manures, the quantity of organic manures 1/3 each of green leaf manure (GLM), farm yard manure (FYM), FYM enriched compost (EC), vermicompost in combination were applied equivalent to recommended dose of nitrogen. Based on phosphorus and potassium content of organics it was confirmed that this quantity of organic manures will meet the recommended quantity of phosphorus and potassium.

All the organic manures equivalent to RDN were applied 15 days before sowing except vermicompost which was applied at grand growth stage (GGS). The sub plots received three liquid organic sprays at GGS and tasseling as per the treatments. The recommended chemical fertilizer (RDF) treatment received 50 per cent RDN and full phosphorus, potassium and $ZnSO_4$ at sowing and 50 per cent RDN was applied at GGS. Recommended package received RDF with FYM @ 7.5 t ha^{-1} which was applied 15 days before sowing. In organic treatments weeds and pests were managed by cultural practices and by using bio-pesticides.

The yield parameters recorded on five plants which were selected randomly from the net plot area and tagged for observations. The cobs were harvested fresh when they attained milky stage, cobs from each net plot were harvested and weighed and was taken with husk, without husk cob weight per plant, fresh cob yield per ha was computed. After harvest of fresh cobs were removed grains and taken fresh and dry grain weight per plant.

The dehydrogenase activity in the soil samples was determined by following the procedure as described by Casida *et al.* (1964). Ten g of soil and 0.2 g $CaCO_3$ were thoroughly mixed and dispensed in the conical flasks. Each flask was added with 1.0 ml of 1.5 per cent, 2, 3, 5-triphenyl tetrazolium chloride (TTC), 1.0 ml of 1 per cent glucose solution and 8.0 ml of distilled water to leave a thin film of water above soil layer. The flasks were stoppered with rubber bunks and incubated at 30°C for 24 hours. At the end of incubation, the contents of the flask were rinsed down into small beaker and a slurry was made by adding 10 ml of methanol. The slurry was filtered through Whatman number 42 filter paper. Repeated rinsing of soil with methanol was continued till the filtrate ran free of red colour. The filtrate was made upto 50 ml with methanol in volumetric flask. The intensity of red colour was measured at 485 nm against a methanol blank using spectrometer.

Grain of fresh cobs from readily selected five kernel plants in the plot area were separated and studied for quality parameters.

Reducing content of sweet corn kernel was estimated by Somogyi (1945) method and was expressed in percentage. Total sugar content of sweet corn kernel was estimated by the same procedure of reducing sugar. Non-reducing sugar was calculated by using a formula given below and expressed in percentage.

Non-reducing sugar = (Total sugar – reducing sugar)×0.95

The nitrogen content of sweet corn kernel was estimated by modified microkjeldhal's method (Jackson, 1973). The protein content was calculated by multiplying the nitrogen content with factor 6.25 and expressed in percentage. Fresh sweet corn cobs were given to a panel of members to know the consumer acceptance and they were asked to grade the sweet corn kernels based on relative total soluble solids. The carbohydrate content of sweet grain was estimated by Anthron method as suggested by Hedge and Hofreiter (1962). It was expressed in percentage and results were tabulated.

Liquid organic manures mainly *Panchagavya*, bio-digester was done by following the standard procedures and *Panchagavya* was sprayed at 3 per cent and bio-digester was sprayed at 10 per cent. The fresh cow urine was collected and sprayed at 10 per cent.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Yield :

The application of RDF and RPP had significant influence on fresh cob yield (6254 and 6222 kg/ ha) as against organic manurial treatments (Table 1). The extent of increase in fresh cob yield of sweet corn with RDF and RPP was more over only organic sources treatment. The balanced supply of nutrients to the sweet corn helped in improving growth and yield, FYM applied along RDF helps to improved the nutrient use efficiency by reducing loss of nutrients when fertilizer applied with farm yard manure. It also helped in improving soil structure and provided better soil environment. Maximum maize yield of 14.4 t per ha with FYM along with the highest N, P_2O_5 and K_2O ha^{-1} rates (200:120:60 kg per ha) with or without zinc and copper were observed (Ibragimov, 1990). This inturn resulted in higher dry matter accumulation in leaves at 7.5 t FYM + RDF over organic sources which ultimately increased the production of photosynthates and higher yield.

A maximum fresh cob yield (5594 kg/ ha) was recorded by bio-digester liquid @ 10 per cent and was at par with cow urine @ 10 per cent and *Panchagavya* @ 3 per cent spray (5078 and 5262 kg ha^{-1}, respectively) (Table 1). This is mediated by biological process as noticed by increased microbial activity and soil enzymatic activity. Further, addition to the supplementation of foliar sprays of bio-digester liquid, *Panchagavya* and cow urine recorded higher fresh cob yield, which might be due to bio-digester liquid and *Panchagavya* contains nutrients, micro-organisms and plant growth promoters as reported by Hazarika *et al.* (2006).

The interactions of RPP + bio-digester liquid @ 10 per cent spray yielded significantly higher fresh cob yield (7067 kg/ha) compared with rest of interactions. Significantly lower fresh cob yield was observed with organics alone over inorganics combined with liquid spray application due to slow release of nutrients and also it will not meet the demand. Foliar application of cow urine and bio-digester helped to increase the fresh cob yield due to its readily available nutrients and also due to growth promoting substances and hormones. Magdoff and Amadon (1980) were of the opinion that application of both manure and inorganic N necessary to obtain maximum yields of corn.

Among the organic manurial treatments, significantly higher with husk and without husk cob weight per plant (389.3 and 378.4 g) was recorded in RDF over rest of the treatments (Table 1). This might be due to increased LA, LAI, total dry matter production *i.e.* photosynthetic area in RDF helped to produce more yield. Similar results indicating the effect of fertilizers along with FYM on yield components in maize were increased reported by Nunez and Miller (1988) and Singh and Agrawal (2004).

Significantly higher with husk and without husk cob weight per plant (333.0 and 326.4 g) was recorded in *Panchagavya* @ 3 per cent spray over bio-digester and cow urine sprays. Higher LAI and nutrient uptake might have contributed higher yield and yield attributes in maize by application of bio-digester liquid, *Panchagavya* and cow urine spray opined by Sathiyamoorthi (1997).

The treatment combinations yielded significantly higher with husk and without husk cob weight per plant (473.3 and 468.6 g) was recorded in RDF with *Panchagavya* @ 3 per cent spray over rest of the combinations. Considerably increased the available nutrient status of the soil which might have resulted in higher cob yield as evidenced in (RDF) (100:50:25 N, P_2O_5, K_2O kg ha^{-1}) + 10 kg $ZnSO_4$) treatment fallowed by (RPP) (7.5 t FYM + RDF (100:50:25 N, P_2O_5, K_2O kg/ ha) + 10 kg $ZnSO_4$) treatment.

Cob girth and length :

The data on main plot revealed that, significantly higher cob girth and cob length was observed in RPP (15.97 and 16.19 cm) over rest of the treatments (Table 2). This might be due to increased availability of nutrients ultimately improved assimilation rate and nutrient uptake and yield attributes over organic manure sources. Application of 50 per cent recommended dose of phosphorus through RDF and 50 per cent through enriched FYM gave significantly higher seed yield (2286 kg/ha) followed by 33 per cent phosphorus through SSP plus 66 per cent through enriched FYM than the recommended practice (Mallikarjuna *et al.*, 1998).

Among different liquid organic manurial treatments, significantly higher cob girth and cob length was observed with bio-digester liquid @ 10 per cent spray (13.48 cm) (Table 2). This was attributed as they provide greater quantity of nutrients and growth promoting substances. Timely foliar nutrition of bio-digester, cow urine and *Panchagavya* improved the yield components. The

Table 1 : With and without husk cob weight (g), fresh and dry grain weight (g) per plant and fresh cob yield (kg ha^{-1}) of sweet corn as influenced by different organics and conventional nutrient management practices

Treatments	Fresh cob yield (kg ha^{-1})	With husk cobs wt. (g/plant)	Without husk cobs wt. (g/plant)	Fresh grain weight (g) per plant	Dry grain weight (g) per plant
Main plot (Organic manures)					
M_1- GLM+FYM+VC (Basal) eq. RDN	4608 c	236.3 d	235.7 d	144.9 d	53.74 d
M_2- GLM+EC+VC (Basal) eq. RDN	4553 c	231.0 d	221.5 e	154.6 c	53.40 d
M_3- GLM+FYM+VC (Top dressing at GGS)	5413 c	317.9 c	307.2 c	153.3 c	64.87 c
M_4- GLM+EC+VC (Top dressing at GGS)	4384 c	231.5 d	231.3 d	167.1 b	70.91 b
M_5- (100:50:25 N, P_2O_5, K_2O kg/ha) + 10 kg $ZnSO_4$ (RDF)	6254 a	389.3 a	378.4 a	176.5 a	79.03 a
M_6-7.5 t FYM+RDF(100:50:25 N, P_2O_5, K_2O kg/ha) + 10 kg $ZnSO_4$ (RPP)	6222 a	366.8 b	350.9 b	172.0 ab	81.03 a
S.E. ±	309.62	3.4	2.8	3.09	1.38
Sub-plot (Liquid organic manures)					
S_1- Bio-digester liquid spray @ 10% at GGS and tasseling stage	5594 a	308.7 b	307.4 b	167.7 a	74.18 a
S_2- *Panchagavya* spray @ 3% at GGS and tasseling stage	5262 ab	333.0 a	326.4 a	169.8 a	70.66 b
S_3- Cow urine spray @ 10% at GGS and tasseling stage	5078 ab	285.2 c	278.0 c	166.1 a	69.85 b
S_4- Control	5021 b	261.3 d	231.2 d	142.1 b	53.96 c
S.E. ±	198.11	2.9	2.8	1.40	0.96
Interactions (M × S)					
M_1S_1	4965 d-h	272.4 ij	261.7 h	144.0 ij	64.65 ef
M_1S_2	5152 c-h	287.8 g	283.2 i	146.2 h-j	53.33 hi
M_1S_3	3814 h	244.7 kl	230.1 o	152.0 g-i	53.45 hi
M_1S_4	4500 e-h	241.6 ij	235.6 p	137.4 j	43.53 j
M_2S_1	5053 c-h	290.1 g	286.6 hi	156.7 f-h	58.28 f-h
M_2S_2	4370 e-h	241.2 ij	234.5 l	163.2 ef	56.38 gh
M_2S_3	3916 gh	195.3 mn	191.3 no	149.1 g-i	56.34 gh
M_2S_4	4872 d-h	193.8 n	173.6 o	149.5 g-i	42.60 j
M_3S_1	6002 a-e	320.7 f	317.2 fg	166.1 d-f	72.93 cd
M_3S_2	5321 b-h	383.6 b	374.5 bc	183.9 ab	73.53 cd
M_3S_3	5724 a-f	315.6 f	313.9 g	150.6 g-i	66.35 de
M_3S_4	4606 e-h	251.9 hi	223.2 lm	112.7 k	46.67 ij
M_4S_1	4650 e-h	232.3 l	217.2 kl	170.4 c-e	77.84 bc
M_4S_2	4356 e-h	265.9 h	257.3 jk	174.0 b-e	72.35 cd
M_4S_3	4185 f-h	230.8 jk	229.3 l	174.9 a-d	72.41 cd
M_4S_4	4344 e-h	211.5 lm	207.1 mn	149.0 g-i	61.03 e-g
M_5S_1	5828 a-f	364.7 c	359.5 cd	184.2 ab	84.60 ab
M_5S_2	6837 ab	473.3 a	468.6 a	177.4 a-c	83.80 ab
M_5S_3	6645 a-c	391.7 b	381.4 b	186.0 a	85.20 ab
M_5S_4	5706 a-f	327.4 ef	304.0 gh	158.5 fg	62.51 e-g
M_6S_1	7067 a	398.1 b	376.1 bc	184.5 ab	86.77 a
M_6S_2	5537 a-g	346.5 d	340.4 de	173.9 b-e	84.59 ab
M_6S_3	5844 a-f	380.7 bc	350.4 de	184.2 ab	85.37 ab
M_6S_4	6439 a-d	341.8 de	336.7 ef	145.4 h-j	67.40 de
S.E. ±	485.27	30.0	28.9	3.43	2.36

application of bio-digester spray and *Panchagavya* liquid manure increased the cob length and cob girth of maize as it was supplied the required metabolites to the source and further greater accumulation of assimilates in the sink (Velu, 2002).

Interaction effects of RDF + cow urine @ 10 per cent spray recorded significantly higher cob girth (16.67 cm) and cob length (16.84 cm) in RPP + bio-digester liquid @ 10 per cent spray combination over rest of interactions. This might be due to balanced supply of nutrients through FYM applied along RDF (100:50:25 N, P_2O_5, K_2O kg ha^{-1}) + 10 kg $ZnSO_4$ and liquid manures to the sweet corn helped in improving yield and yield attributes. The application of bio-digester spray and *Panchagavya* liquid manure and FYM along with the highest N, P_2O_5 and K_2O ha^{-1} rates (200:120:60 kg per ha) with or without zinc and copper were observed increased the cob length and cob girth of maize as it was supplied the required metabolites to the source and further greater accumulation of assimilates in the sink opined by Velu (2002) and Ibragimov (1990).

Fresh and dry grain weight per plant :

Significantly higher fresh and dry grain weight per plant (176.5 and 79.03 g) was recorded in RDF and RPP (172.0 and 81.03 g) treatment over organic combinations (Table 2). The maximum utilization of N, P_2O_5, K_2O and $ZnSO_4$ along with FYM by the plant resulted in increased productivity in terms of carbohydrate production which contributed to the increased yield if the total storage capacity (sink) of the plant is adequate. This means that the sufficient number of grains was produced and the development was adequate. Combined application of RDF + FYM @ 10 t per ha + soil application of $ZnSO_4$ @ 10 kg per ha recorded significantly higher grain yield (38.65 q/ha) when compared to other treatment combinations reported by Chandrakumar *et al.* (2004).

A all liquid organic manure treatments, did not differ significantly with each other on fresh grain weight per plant, but significantly higher dry grain weight per plant (74.18 g) was recorded in bio-digester liquid @ 10 per cent spray over other treatments. Production of dry matter is represented by crops photosynthetic dry weight, which depends on production area of photosynthetic system and rate of assimilation per unit area and ultimately increased grain yield of maize which were influenced with the application of bio-digester and cow urine sprays opined by Patel *et al.* (1999).

The interaction effect of RDF + cow urine @ 10 per cent spray (186.0 g) yielded significantly higher fresh grain weight per plant (186.0 g) and RPP + bio-digester liquid @ 10 per cent spray (86.77 g) recorded significantly higher dry grain weight per plant as compared to other treatment combinations. Foliar application of cow urine and bio-digester along with chemical fertilizers helped to increase the grain yield due to its readily available nutrients and also due to growth promoting substances and hormones. Magdoff and Amadon (1980) were of the opinion that application of both manure and inorganic N necessary to obtain maximum yields of corn.

Protein content :

The RPP and RDF treatment resulted high content of protein (9.94 and 9.67 %) in the grains (Table 3). Among organics GLM + EC + VC (top dressing at GGS) (9.27%) treatment produced significantly higher protein content over other organics. This might attributed the role N and Zn helps an important role in synthesis of nucleic acid and protein. Significantly higher protein content of maize with 150 kg N over the 120 kg N per ha and no nitrogen reported by Muthukrishna and Subramanian (1980). The increased nutrient uptake in treatment receiving vermicompost applied in top dressing at grand growth stage can be well supported by the increased yield levels of sweet corn, over vermicompost applied at basal. The application of vermicompost @ 5.0 t per ha to sugarcane increased the sugar recovery by 0.92 per cent compared to application of chemical fertilizers (Hapse, 1993).

The significantly higher protein content (9.27%) was recorded with cow urine @ 10 per cent spray over rest of the treatments. This might be contributed by presence uric acid and plant growth substances in cow urine. Application of *Panchagavya* and bio-digester foliar sprays at cob formation stage of maize enhanced the protein and carbohydrates content opined by Singh and Singh (1968).

Significantly higher protein content was recorded in RPP + cow urine @ 10 per cent spray (10.40%) over other combinations. This might be due to the presence of essential plant nutrients in *Panchagavya* and uric acid and plant regulatory substances in cow urine help to increasing quality characters of sweet corn. The absence of either FYM with inorganic fertilizer is found to be reflected in higher protein value of the maize grain reported by Reddy *et al.* (1990) and the continuous organic farming is of considerable value in increasing the protein (Addy *et al.*, 1987).

Table 2 : Cob girth (cm), cob length (cm) and fresh and dry grain weight (g) per plant of sweet corn as influenced by different organics and conventional nutrient management practices

Treatments	Cob girth (cm)	Cob length (cm)	Fresh grain weight (g) per plant	Dry grain weight (g) per plant
Main plot (Organic manures)				
M_1- GLM+FYM+VC (Basal) eq. RDN	11.02 d	10.98 e	144.9 d	53.74 d
M_2- GLM+EC+VC (Basal) eq. RDN	12.78 c	11.66 d	154.6 c	53.40 d
M_3- GLM+FYM+VC (Top dressing at GGS)	12.72 c	11.78 d	153.3 c	64.87 c
M_4- GLM+EC+VC (Top dressing at GGS)	13.29 b	12.35 c	167.1 b	70.91 b
M_5- (100:50:25 N, P_2O_5, K_2O kg/ha) + 10 kg $ZnSO_4$ (RDF)	15.93 a	14.03 b	176.5 a	79.03 a
M_6-7.5 t FYM+RDF(100:50:25 N, P_2O_5, K_2O kg/ha) + 10 kg $ZnSO_4$ (RPP)	15.97 a	16.19 a	172.0 ab	81.03 a
S.E. ±	0.16	0.15	3.09	1.38
Sub-plot (Liquid organic manures)				
S_1- Bio-digester liquid spray @ 10% at GGS and tasseling stage	14.14 a	13.48 a	167.7 a	74.18 a
S_2- *Panchagavya* spray @ 3% at GGS and tasseling stage	13.71 a	12.88 a	169.8 a	70.66 b
S_3- Cow urine spray @ 10% at GGS and tasseling stage	13.89 a	13.29 a	166.1 a	69.85 b
S_4- Control	12.73 b	11.68 b	142.1 b	53.96 c
S.E. ±	0.23	0.23	1.40	0.96
Interactions (M × S)				
M_1S_1	12.06 g-i	11.43 e-h	144.0 ij	64.65 ef
M_1S_2	11.33 h-j	12.09 e-g	146.2 h-j	53.33 hi
M_1S_3	10.92 i-j	10.47 g-h	152.0 g-i	53.45 hi
M_1S_4	9.763 j	9.92 h	137.4 j	43.53 j
M_2S_1	13.20 e-h	12.73 d-e	156.7 f-h	58.28 f-h
M_2S_2	13.13 e-h	11.67 e-h	163.2 ef	56.38 gh
M_2S_3	12.92 e-h	11.56 e-h	149.1 g-i	56.34 gh
M_2S_4	11.88 g-i	10.68 f-h	149.5 g-i	42.60 j
M_3S_1	14.27 b-e	12.53 d-f	166.1 d-f	72.93 cd
M_3S_2	12.72 e-i	11.24 e-h	183.9 ab	73.53 cd
M_3S_3	12.19 f-i	12.84 d-e	150.6 g-i	66.35 de
M_3S_4	11.70 h-i	10.52 g-h	112.7 k	46.67 ij
M_4S_1	13.05 e-h	13.10 d-e	170.4 c-e	77.84 bc
M_4S_2	13.74 d-g	11.83 e-h	174.0 b-e	72.35 cd
M_4S_3	14.04 c-f	12.64 d-e	174.9 a-d	72.41 cd
M_4S_4	12.34 f-i	11.83 e-h	149.0 g-i	61.03 e-g
M_5S_1	15.83 a-c	14.25 b-d	184.2 ab	84.60 ab
M_5S_2	16.08 ab	14.04 c-d	177.4 a-c	83.80 ab
M_5S_3	16.67 a	15.95 a-b	186.0 a	85.20 ab
M_5S_4	15.14 a-d	11.87 e-g	158.5 fg	62.51 e-g
M_6S_1	16.42 a	16.84 a	184.5 ab	86.77 a
M_6S_2	15.29 a-d	16.42 a	173.9 b-e	84.59 ab
M_6S_3	16.61 a	16.28 a	184.2 ab	85.37 ab
M_6S_4	15.56 a-d	15.23 a-c	145.4 h-j	67.40 de
S.E. ±	0.57	0.56	3.43	2.36

Reducing and non-reducing sugars :

Reducing and non-reducing sugar content (3.65, 3.57% and 20.76, 21.40%) was significantly higher recorded in RDF and RPP treatments. However, significantly lower reducing and non-reducing sugar content (2.57%) was recorded in GLM + FYM + VC (basal) equivalent to RDN. This might be to increased availability of N, P, K in RPP and RDF promoted the improving reducing and non-reducing sugars than organic manures.

Among liquid manures, *Panchagavya* @ 3 per cent spray recorded significantly higher reducing sugar content (3.50%) and non-reducing sugar content (20.21%) significantly higher was recorded in bio-digester liquid @ 10 per cent spray treatment (Table 3). This might be due to increased availability of nutrients and nutrient uptake ultimately increases the reducing sugar. The kernel weight of sweet corn, reducing sugar, non-reducing sugar, total sugar and protein content in grain was significantly increased with increase in nitrogen levels (Raja, 2001).

The treatment combinations of RDF + *Panchagavya* @ 3 per cent spray (3.82%) and RDF + cow urine @ 10 per cent spray were found significantly higher reducing sugar content (3.82%) over rest of the treatment combinations. While, significantly higher non-reducing sugar content (22.90%) recorded in RDF + control treatment. This might due to efficient use of soil moisture due to better root growth caused by better availability of nutrients helped improving the sugar content in grains.

Total sugar and total soluble solids :

Total sugar content (24.97 %) and total soluble solids (13.08 %) (T.S.S %) in sweet corn kernels were significantly higher observed in RPP (Table 3). This might be due to more availability of nutrients. Similarly, highest sugar content in sweet corn grain at green stage was found under 50 kg P_2O_5 + 50 kg K_2O ha^{-1} opined by Gawade (1998).

Among liquid manures bio-digester liquid @ 10 per cent spray and cow urine @ 10 per cent spray treatment yielded significantly higher total sugar and total soluble solids (23.16 and 23.10, 12.14 and 12.22 %), respectively. This might be contributed by presence uric acid and plant growth substances in cow urine. Application of *Panchagavya* and bio-digester foliar sprays at cob formation stage of maize enhanced the protein and carbohydrates content (Singh *et al.*, 1968).

The interactions data revealed that, significantly higher total sugar content (26.33%) and total soluble solids (13.60%) was recorded with application of RDF + control and RPP + bio-digester liquid @ 10 per cent spray. While, significantly lower total sugar content (18.28%) was recorded in GLM + FYM + VC (basal) equivalent to RDN + *Panchagavya* @ 3 per cent spray and total soluble solids was noticed in all organic manure combinations. Due to more availability of moisture and K and Zn helped to improving total sugar and total soluble solids. TSS (%) and protein content (24.13%) in seeds increased with increasing levels of phosphorus upto 60 kg per ha to pea crop reported by Shukla *et al.* (1997).

Total carbohydrates :

Total carbohydrates content (78.36 and 76.15%) significantly higher was recorded in RDF over rest of treatments. This might due to better root growth caused by better availability of P and K helped in increasing quality characters of sweet corn.

Significantly higher total carbohydrates content in *Panchagavya* @ 3 per cent spray over rest of the treatments. Due to presence of essential plant nutrients and plant regulatory substances in *Panchagavya*.

Interaction effects indicated that, RDF along with bio-digester liquid @ 10 per cent spray recorded significantly higher total carbohydrates content (80.24%) (Table 3). This might be due to better development of root system helped for utilization of nutrients and ultimately improved carbohydrates content. The both carbohydrate and fibre contents of sweet sorghum was higher with combined application of organic and inorganic nutrients reported by Almodares *et al.* (2009).

Dehydrogenase activity :

Among solid organic manurial sources, significantly higher dehydrogenase activity (33.29 πg TPF/ g soil/ day) was recorded in GLM + FYM + VC (top dressing at GGS) and GLM + EC + VC (basal) equivalent to RDN (33.07 πg TPF/ g soil/day) over rest of the treatments (Table 3). This might be due to more microbial activity hence, ultimately increased enzymatic activity.

The sub-plot treatments data showed that there were no significant differences among liquid organic manurial treatments and were significantly superior over control.

Interaction effects showed that, significantly higher dehydrogenase activity (34.79 πg TPF/ g soil/day) was

Table 3 : Protein (%), reducing sugar (%), non-reducing sugar (%), total sugar (%), TSS (%) and total carbohydrates (%) content in sweet corn and dehydrogenase activity (µg TPF g^{-1} soil /day) as influenced by different organic and conventional nutrient management practices

Treatments	Protein (%)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)	TSS (%)	Total carbohydrates (%)	Dehydrogenase activity (µg TPF g^{-1} soil /day)
Main plot (Organic manures)							
M_1- GLM+FYM+VC (Basal) eq. RDN	8.66 c	2.57 e	19.46 d	19.04 f	11.75 c	67.85 d	31.30 b
M_2- GLM+EC+VC (Basal) eq. RDN	8.17 d	2.76 d	19.18 d	21.95 e	11.77 c	68.34 d	33.07 a
M_3- GLM+FYM+VC (Top dressing at GGS)	8.24 d	3.42 c	19.36 d	22.79 d	11.70 c	73.87 c	33.29 a
M_4- GLM+EC+VC (Top dressing at GGS)	9.27 b	3.51 b	20.41 c	23.92 c	11.35 d	76.15 b	31.77 b
M_5- (100:50:25 N, P_2O_5, K_2O kg ha^{-1}) + 10 kg $ZnSO_4$ (RDF)	9.67 a	3.65 a	20.76 b	24.41 b	12.52 b	78.36 a	24.96 c
M_6-7.5 t FYM+RDF(100:50:25 N, P_2O_5, K_2O kg ha^{-1}) + 10 kg $ZnSO_4$ (RPP)	9.94 a	3.57 b	21.40 a	24.97 a	13.08 a	77.21 b	23.03 d
S.E. ±	0.14	0.02	0.11	0.10	0.05	0.50	0.46
Sub-plot (Liquid organic manures)							
S_1- Bio-digester liquid spray @ 10% at GGS and tasseling stage	8.94 b	3.36 b	20.21 a	23.16 a	12.14 a	74.31 b	30.62 a
S_2- *Panchagavya* spray @ 3% at GGS and tasseling stage	9.21 a	3.50 a	19.21 c	22.56 b	11.96 b	76.36 a	30.34 a
S_3- Cow urine spray @ 10% at GGS and tasseling stage	9.27 a	3.34 b	19.76 b	23.10 a	12.22 a	73.26 c	30.23 a
S_4- Control	8.55 c	2.95 c	19.20 c	22.56 b	11.79 b	70.60 d	27.09 b
S.E. ±	0.08	0.01	0.10	0.10	0.07	0.40	0.35
Interaction (M × S)							
M_1S_1	8.80 e-g	2.65 l	16.22 n	18.87 m	11.47 d	67.88 ij	32.52 a-d
M_1S_2	8.78 e-g	2.50 m	15.78 n	18.28 m	11.47 d	71.64 gh	31.82 b-e
M_1S_3	8.65 f-h	2.83 k	17.47 m	20.30 l	12.47 c	68.72 hi	31.65 b-f
M_1S_4	8.42 g-i	2.31 n	16.38 n	18.69 m	11.60 d	63.15 k	29.19 e-f
M_2S_1	7.76 jk	3.21 i	18.78 j-l	21.99 i-k	11.53 d	67.37 ij	34.11 ab
M_2S_2	8.89 e-g	2.91 k	18.59 kl	21.50 k	11.60 d	72.92 fg	34.28 ab
M_2S_3	8.66 f-h	2.52 m	19.92 f-h	22.44 g-j	12.53 bc	67.82 ij	34.14 ab
M_2S_4	7.38 k	2.42 m	19.44 g-k	21.86 jk	11.40 d	65.27 jk	29.76 d-f
M_3S_1	8.11 h-j	3.35 gh	19.65 g-i	23.00 f-h	12.33 c	75.87 c-f	34.79 a
M_3S_2	7.98 i-k	3.68 bc	18.51 l	22.19 h-k	11.60 d	76.49 b-e	33.59 a-c
M_3S_3	8.57 g-i	3.63 cd	19.16 h-l	22.79 f-i	11.33 d	73.48 e-g	33.99 ab
M_3S_4	8.30 g-j	3.04 j	20.12 fg	23.17 e-g	11.53 d	69.64 hi	30.78 c-f
M_4S_1	9.24 d-f	3.82 a	19.58 g-j	23.40 d-f	11.40 d	75.59 d-f	32.93 a-c
M_4S_2	9.42 c-e	3.50 ef	20.66 ef	24.16 cd	11.00 d	79.45 ab	33.18 a-c
M_4S_3	9.66 b-d	3.49 ef	19.69 g-i	23.19 e-g	11.60 d	74.95 d-f	32.04 a-d
M_4S_4	8.77 fg	3.25 hi	21.69 bc	24.94 bc	11.40 d	74.61d-g	28.93 f
M_5S_1	9.97 a-c	3.55 de	18.84 i-l	22.40 g-j	12.53 bc	80.24 a	25.53 g
M_5S_2	10.18 ab	3.82 a	20.16 fg	23.98 de	12.60 bc	79.68 ab	25.95 g
M_5S_3	9.67 b-d	3.82 a	21.12 c-e	24.94 bc	12.33 c	77.55 a-d	25.93 g
M_5S_4	8.86 e-g	3.42 fg	22.90 a	26.33 a	12.60 bc	75.98 c-f	22.41 h
M_6S_1	9.75 b-d	3.56 de	22.16 ab	25.72 ab	13.60 a	78.92 a-c	23.82 g-h
M_6S_2	10.05 a-c	3.68 bc	21.54 b-d	25.23 b	13.47 a	77.97 a-d	23.21 g-h
M_6S_3	10.40 a	3.77 ab	21.19 c-e	24.96 bc	13.07 ab	77.03 a-d	23.62 g-h
M_6S_4	9.58 b-d	3.26 hi	20.71 d-f	23.98 de	12.20 c	74.92 d-f	21.45 h
S.E. ±	0.19	0.03	0.26	0.26	0.18	1.00	0.85

recorded in GLM + FYM + VC (top dressing at GGS) + bio-digester liquid @ 10 per cent spray over rest combinations. Due to combined application of organic and liquid organic manures helped better microbial activity. The results corroborate with the findings of Ghai *et al.*(1988) who reported that inclusion of legumes in rice based cropping increased the activity of rhizospheric soil and further reported that activity decreased with soil depth.

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