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Studies on Effect of Green Manuring and Different Organic Sources of Nutrients on Growth and Yield of Maize in Maize - Cowpea Cropping Sequence

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Abstract

A field experiment was conducted at research and demonstration block of Research Institute on Organic Farming, UAS, GKVK, Bengaluru during 2022-23 and 2023-24 to study the effect of green manuring and different organic sources of nutrients on growth and yield of maize in maize-cowpea cropping sequence. The experiment was laid out in a split plot design with three replications. The experiment consisted of 18 treatment combinations which consisted of two main plots *i.e.* with and without *in situ* incorporation of sun hemp as a green manure crop and nine subplots comprising three levels of N equivalent and four organic sources of nutrients. The soil at experimental site was red sandy loam having medium organic carbon (0.64 %), available N (291.2 kg ha^{-1}), available P_2O_5 (26.24 kg ha^{-1}) and available K_2O (228.3 kg ha^{-1}) content. The experimental results indicated that *in situ* incorporation of green manure along with the integrated application of 25% N equivalent FYM + 25% N equivalent poultry manure + 25% N equivalent vermicompost + 25% N equivalent *jeevamrutha* for maize crop resulted in significantly higher plant height, leaf area, total dry matter accumulation, kernel yield, stover yield and B:C ratio. This was followed by the combination of green manuring with 50% N equivalent FYM + 50% N equivalent poultry manure which resulted in higher plant height, leaf area, total dry matter accumulation, kernel yield, stover yield of maize and B:C ratio.

Keywords : Cropping sequence, Green manure, N equivalent, Organic sources

Organic farming is a holistic production system that promotes soil health, environmental sustainability and human well-being. Compared to chemical farming, it offers numerous advantages, including reduced pollution, enhanced soil properties and minimized risks to human and animal health. Organic agriculture sustains productivity by improving soil health and optimizing natural resource use, thereby ensuring long-term benefits for future generations. Additionally, it reduces the risk of crop failure, enhances soil structure, aeration, water retention and erosion control and improves nutrient availability while minimizing nutrient losses into water bodies.

Globally, organic agriculture is practiced in 189 countries over 76.5 million hectares, involving 3.1 million farming households (Willer Helga *et al*., 2023). In India, 2.3 million hectares are under organic farming, with Karnataka contributing 0.11 million hectares and producing 28.76 million tonnes (Anonymous, 2023). Nutrients are crucial for crop growth and yield and their integrated application reduces cultivation costs while enhancing soil fertility (Mahajan and Sharma, 2005). Continuous use of chemical fertilizers, however, depletes soil organic carbon (SOC) and leads to nutrient imbalances, negatively affecting soil quality and crop yields (Muchhadiya *et al*., 2021). SOC, a key indicator of soil health, can be improved through practices like regular organic manure application, crop rotation, conservation agriculture and green manuring.

Green manuring, one of the oldest nutrient management practices, involves incorporating fresh plant biomass into the soil to enhance its nutrient content. This practice provides nitrogen fixation, nutrient conservation and improved soil properties, offering a cost-effective alternative to nitrogen fertilizers (Kamal *et al*., 2006). Organic manures, such as farmyard manure (FYM), vermicompost, poultry manure and liquid formulations like jeevamrutha, serve as effective substitutes for chemical fertilizers. These organic inputs improve soil fertility and crop productivity through enhanced nutrient release and microbial activity.

Maize, the 'Queen of cereals,' is a globally important crop with high genetic yield potential. In India, it is grown on 9.56 million hectares, producing 28.76 million tonnes with a productivity of 3006 kg ha^{-1}. Karnataka accounts for 14.88 per cent of India's maize production (Anonymous, 2023). Cowpea, a protein-rich legume, complements maize in cropping systems by fixing atmospheric nitrogen, enhancing microbial activity and maintaining soil properties. It is cultivated on 0.91 lakh hectares in Karnataka, producing 0.52 lakh tonnes with a productivity of 572 kg ha^{-1} (Anonymous, 2023).

The maize-cowpea cropping sequence efficiently utilizes residual soil nutrients and water, enhancing system productivity and sustainability (Parihar *et al*., 2011). Diversifying organic nutrient sources, such as combining green manures with FYM, poultry manure, vermicompost and jeevamrutha, significantly boosts crop yield while minimizing chemical fertilizer reliance (Giraddi, 2000). These practices improve soil structure and enhance physical, chemical and biological parameters, ensuring long-term soil fertility.

Considering the environmental impact of chemical fertilizers and the growing demand for organically grown food, adopting organic nutrient sources provides a sustainable solution. Organic farming not only ensures chemical-free food but also supports soil health and environmental sustainability. This study evaluates the effect of green manuring and various organic nutrient combinations on the growth and yield of maize in a maize-cowpea cropping sequence, highlighting the potential of organic practices in sustainable agriculture.

MATERIAL AND METHODS

Field experiments were conducted during 2022-23 and 2023-24 at organic farming research and demonstration block of Research Institute on Organic Farming (RIOF), Gandhi Krishi Vignan Kendra (GKVK), University of Agricultural Sciences, Bangalore. It is situated in Eastern Dry Zone of Karnataka at 13 ° 09' North latitude, 77 ° 57' East longitude and at an altitude of 924 m above mean sea level (MSL). The soil of the experimental site was red sandy clay loam grouped under the class of *Alfisols*. The soil of experimental site was generally acidic in reaction (pH 6.42), medium in available nitrogen (291.2 kg N ha^{-1}), medium in available phosphorous (26.24 kg P_2O_5 ha^{-1}) and medium in available potassium (228.3 kg K_2O ha^{-1}). The organic carbon content of the experimental site was medium (0.64%). The Studies were conducted to know the influence of green manuring and different organic sources on growth and yield of maize in maize-cowpea cropping sequence during *rabi* 2022 and 2023 followed by cowpea to assess the residual effect of organic sources on growth and yield of cowpea. The experiment was laid out in a split plot design with three replications. The experiment consists of 18 treatment combinations which consisted of two main plots *i.e.,* with and without *insitu* incorporation of sun hemp as a green manure crop and nine subplots comprising three levels of N equivalent and four organic sources of nutrients *i.e.,* G_0: Without green manure; G_1: With green manure; M_1: No manure; M_2: 100% N equivalent FYM; M_3: 100% N equivalent poultry manure; M_4: 100% N equivalent vermicompost; M_5: 100% N equivalent jeevamrutha; M_6: 50% N equivalent FYM + 50% N equivalent poultry manure; M_7: 50% N equivalent FYM + 50% N equivalent vermicompost; M_8: 50% N equivalent FYM + 50% N equivalent jeevamrutha; M_9: 25% N equivalent FYM + 25% N equivalent poultry manure + 25% N equivalent vermicompost + 25% N equivalent jeevamrutha. The average rainfall received during crop growth period was 441.2 mm.

Crop Husbandry Practices

For sun hemp *insitu* incorporation, the experimental field was ploughed twice with a tractor drawn cultivator and later harrowed with a rotavator to get a fine tilth. The area was cleared off weed trash and divided into the required number of plots. Sowing of sun hemp done through broadcasting method on 24th June 2022 and 15th July 2023. The broadcasting of seeds of sunnhemp green manure crop were taken up @ 25 kg ha^{-1} on as per the systems of green manuring *in-situ* in plots. Green manure sunnhemp was incorporated after attaining 45 days of growth in all the systems in plots. Sowing time of green manure crop was adjusted in such a way that the sowing of maize was same for all the treatments. Incorporation of green manure in this system was done when green manure crop attained 7 weeks age. Tractor operated rotovator was used to incorporate green manure crop.

For maize crop, the experimental plot was ploughed once with the tractor drawn disc plough followed by secondary tillage using cultivator and rotovator twice to break the clods and soil was brought to fine tilth. The land was further laid into experimental units of 5.4 m × 3.6 m with irrigation channels between two units. The stubbles and weeds were removed from the experimental area and the land within the plot was levelled. Each plot was provided with bunds of 20 cm width and 15 cm height and one meter between replications. Without disturbing the existing bunds land was tilled manually to create a fine seed bed for sowing of cowpea crop. After bringing the soil to a fine tilth, based on the N equivalent basis farmyard manure, vermicompost and poultry manure were applied to each plot prior to sowing and recommended jeevamrutha incorporated well in soil at 20 and 40 DAS. Nutrient composition of green manure crop and organic manures *viz*., Farmyard manure, vermicompost, poultry manure and jeevamrutha were analyzed and presented below. Organic manures were applied to each treatment on nitrogen equivalent basis. Application of jeevamrutha on N equivalent basis done at 20 DAS and 40 DAS. The nutrient composition of organic manures used in the experiment is presented in Table 1.

Maize hybrid MAH-14-5 seeds were sown with recommended seed rate of 15 kg ha^{-1} at a spacing of 60 X 30 cm on 22nd September, 2022 and 13th October, 2023 during *rabi*. After sowing, seeds were covered with a layer of fine soil firmly and field was irrigated immediately. Uniform plant population was ensured in the experimental plots by dibbling seeds 10 days after sowing wherever seedlings were not emerged. Subsequently thinning operation was carried out at 15 days after sowing and retained only one healthy plant per hill. All the plots were irrigated immediately after sowing. Further, irrigation was given at five days interval during vegetative stage and at three days

TABLE 1

Nutrient composition of organic manures and green manure

Organic manure	N %			P_2O_5 (%)			K_2O (%)		
	I	II	Mean	I	II	Mean	I	II	Mean
Farm yard manure	0.49	0.53	0.51	0.26	0.24	0.25	0.47	0.51	0.49
Vermicompost	1.54	1.48	1.51	0.54	0.59	0.56	1.28	1.30	1.29
Poultry manure	2.21	2.18	2.19	1.62	1.65	1.63	1.34	1.29	1.31
Jeevamrutha	1.06	1.14	1.10	0.44	0.42	0.43	0.38	0.31	0.34
Green manure (Sunhemp)	0.88	0.94	0.91	0.15	0.17	0.16	0.52	0.56	0.54

Note : I: *Rabi* 2022; II: *Rabi* 2023 interval during reproductive stage of crop depending upon the weather conditions. Irrigation was skipped when rainfall was received and it was stopped a week prior to crop harvest. Hand weeding was done twice at 20 and 40 DAS to keep weed free during critical crop growth period and earthing up was done at 30 DAS to facilitate root development and firm anchorage both in maize and cowpea crop. At early stage of the crop growth there was incidence of fall army worm in maize, necessary protective measure was taken to control them by spraying concentrated neem oil at 10 ml l^{-1} of water as well Spinosad 45 SC @ 0.3 ml l^{-1} of water for maize crop. Harvesting was done when the cob sheath turned brownish yellow and silk was completely dried. The matured cobs were harvested separately as per treatment from the standing plant along with cob sheath. The cobs were shifted to threshing yard and sheath was peeled off. The cobs then dried and threshed using maize sheller. Separated produce was winnowed, cleaned and dried to storable grain moisture content (15.5% moisture). The produce was cleaned and weight of seeds per plot was recorded and the values were converted into hectare basis and expressed in quintals. Cowpea crop (KBC 9) was sown after harvesting maize at a spacing of 45 x 10 cm and crop was raised without application of organic nutrient sources following crop management practices. Neem oil (10 ml l^{-1}) was sprayed to control aphid infestation in cowpea during crop growth stages.

Biometric observations on growth parameters were recorded randomly on selected five plants at 30, 60, 90 days after sowing and at harvest in the net plot. Data related to yield was recorded at the time of harvest of the crop. Based on the observations, data were subjected to statistical analysis as per the procedure outlined by Gomez and Gomez (1984). To know the effect of main plots and sub-plots and to compare their treatment combinations, statistical procedure of split plot design followed.

Results and Discussion

Plant Height (cm)

The pooled data of two seasons pertaining to plant height at different growth stages of maize as influenced by green manuring and different organic sources of nutrients in maize-cowpea cropping sequence is presented in Table 2 and Fig. 1. Plant height of maize varied significantly at 30, 60, 90 DAS and at harvest as influenced by green manuring and different organic sources of nutrients. *Insitu* incorporation of green manure (G_1) recorded significantly higher plant height (46.84, 116.0, 159.6 and 166.4 cm at 30, 60, 90 DAS and at harvest, respectively) as compared to without green manure incorporation (G_0) (33.75, 80.25, 126.4 and 131.9 cm at 30, 60, 90 DAS and at harvest, respectively). Among different organic sources of nutrient combined application of different organic sources of nutrient *i.e.,* 25% N equivalent FYM + 25% N equivalent poultry manure + 25% N equivalent vermicompost + 25% N equivalent jeevamrutha (M_9) recorded significantly higher plant height (47.73, 126.9, 166.4 and 175.5 cm at 30, 60, 90 DAS and at harvest, respectively) followed by combined application of M_6: 50% N equivalent FYM + 50% N equivalent poultry manure (45.57, 112.7, 159.1 and 164.7 cm at 30, 60, 90 DAS and at harvest, respectively) and application of M_7: 50% N equivalent FYM + 50% N equivalent vermicompost (45.16, 108.2, 155.3 and 161.9 cm at 30, 60, 90 DAS and at harvest, respectively) and significantly lower plant height was recorded in no manure (Control) plots (26.16, 57.39, 94.70 and 99.73 cm at 30, 60, 90 DAS and at harvest, respectively). Interaction effect between *Insitu* incorporation of green manure and different organic sources of nutrients was found to be significant. *Insitu* incorporation of green manure *fb* combined application of different organic sources of nutrients *i.e.,* 25% N equivalent FYM + 25% N equivalent poultry manure + 25% N equivalent vermicompost + 25% N equivalent jeevamrutha (G_1M_9) (56.87, 158.2, 188.5 and 204.1 cm at 30, 60, 90 DAS and at harvest, respectively) recorded higher plant height followed by *Insitu* incorporation of green manure *fb* combined application of 50% N equivalent FYM + 50% N equivalent poultry manure (G_1M_6) (52.56, 131.9, 179.6 and 185.3 cm at 30, 60, 90 DAS and at harvest, respectively) and 50% N equivalent

TABLE 2

Plant height (cm) of maize at different growth stages as influenced by green manuring and different organic sources of nutrients in maize-cowpea cropping sequence

Treatment	30 DAYS			60 DAYS			90 DAYS			AT Harvest		
	I	II	Pooled	I	II	Pooled	I	II	Pooled	II	II	Pooled
G_0	33.41	34.08	33.75	74.14	86.35	80.25	124.15	128.61	126.38	128.93	134.89	131.91
G_1	50.05	43.63	46.84	115.43	116.49	115.96	156.53	162.73	159.63	162.91	169.86	166.38
F test	*	*	*	*	*	*	*	*	*	*	*	*
S. Em ±	0.91	1.08	0.99	1.94	2.13	2.03	1.71	1.79	1.75	2.86	4.05	3.42
C.D.(p=0.05)	2.74	3.14	2.98	5.83	6.87	6.05	5.14	5.56	5.25	8.61	12.18	10.35
M_1	25.18	27.15	26.16	53.15	61.63	57.39	92.07	97.32	94.70	98.53	100.93	99.73
M_2	39.00	35.52	37.26	83.81	92.80	88.31	132.93	137.00	134.96	136.90	142.89	139.89
M_3	41.56	40.30	40.93	96.97	101.57	99.27	143.55	147.95	145.75	148.35	154.77	151.56
M_4	41.52	37.80	39.66	93.56	97.41	95.48	139.86	144.33	142.10	146.54	149.84	148.19
M_5	40.29	36.60	38.44	88.34	94.59	91.46	136.01	142.78	139.39	142.18	147.44	144.81
M_6	48.12	43.01	45.57	109.95	115.49	112.72	156.24	161.96	159.10	161.21	168.24	164.72
M_7	47.69	42.64	45.16	106.44	110.03	108.24	152.57	158.12	155.34	157.98	165.88	161.93
M_8	42.79	40.68	41.73	98.43	107.98	103.20	146.76	151.85	149.30	151.74	160.22	155.98
M_9	49.46	46.00	47.73	122.44	131.29	126.86	163.11	169.75	166.43	169.87	181.15	175.51
F test	*	*	*	*	*	*	*	*	*	*	*	*
S. Em ±	1.73	1.75	1.74	3.57	4.13	3.85	4.05	4.57	4.31	4.09	4.75	4.42
C.D.(p=0.05)	5.00	5.08	5.02	10.20	11.90	11.54	11.66	13.18	12.03	11.78	13.68	13.25
G_0M_1	21.03	27.12	24.08	49.83	56.07	52.95	91.97	96.44	94.2	96.61	97.82	97.22
G_0M_2	33.08	27.57	30.33	59.04	76.07	67.56	110.26	116.55	113.4	119.52	126.58	123.05
G_0M_3	33.55	35.78	34.66	76.18	92.11	84.15	127.80	133.01	130.4	130.16	139.82	134.99
G_0M_4	33.53	30.14	31.84	74.51	83.45	78.98	123.70	128.18	125.9	132.71	135.73	134.22
G_0M_5	33.22	28.84	31.03	64.96	78.92	71.94	116.16	120.81	118.5	124.78	130.89	127.84
G_0M_6	36.97	40.18	38.57	89.62	97.40	93.51	136.50	140.60	138.5	140.73	147.53	144.13
G_0M_7	36.38	40.31	38.34	82.62	98.38	90.50	135.95	142.80	139.4	138.25	143.88	141.07
G_0M_8	35.94	36.65	36.29	77.95	96.32	87.14	129.32	136.22	132.8	133.54	142.10	137.82
G_0M_9	37.03	40.14	38.59	92.57	98.47	95.52	145.71	142.92	144.3	144.10	149.64	146.87
G_1M_1	29.33	27.17	28.25	56.47	67.20	61.84	92.17	98.20	95.2	100.45	104.04	102.24
G_1M_2	44.93	43.46	44.20	108.59	109.53	109.06	155.60	157.45	156.5	154.27	159.21	156.74
G_1M_3	49.58	44.82	47.20	117.76	111.02	114.39	159.30	162.89	161.1	166.54	169.72	168.13
G_1M_4	49.51	45.46	47.49	112.60	111.37	111.99	156.02	160.49	158.3	160.37	163.96	162.17
G_1M_5	47.35	44.36	45.85	111.71	110.27	110.99	155.86	164.75	160.3	159.57	163.98	161.78
G_1M_6	59.27	45.85	52.56	130.27	133.59	131.93	175.98	183.32	179.6	181.68	188.95	185.31
G_1M_7	59.00	44.96	51.98	130.26	121.69	125.97	169.19	173.44	171.3	177.70	187.88	182.79
G_1M_8	49.64	44.71	47.17	118.90	119.64	119.27	164.19	167.47	165.8	169.94	178.34	174.14
G_1M_9	61.88	51.87	56.87	152.30	164.11	158.20	180.51	196.58	188.5	195.64	212.65	204.15
F test	*	*	*	*	*	*	*	*	*	*	*	*
S. Em ±	1.73	1.75	1.74	5.05	5.84	5.45	5.72	6.47	6.09	5.78	6.72	6.25
C.D.(p=0.05)	5.00	5.03	5.21	14.56	16.83	15.23	16.49	18.63	18.27	16.66	19.34	18.14

Note : G_0: Without Green manure; G_1: With Green manure ; M_1: No Manure ; M_2: 100 % N equivalent FYM; M_3: 100 % N equivalent Poultry manure; M_4: 100 % N equivalent Vermicompost; M_5: 100 % N equivalent Jeevamrutha; M_6: 50% N equivalent FYM + 50% N equivalent Poultry manure; M_7: 50% N equivalent FYM + 50% N equivalent Vermicompost; M_8: 50 % N equivalent FYM + 50 % N equivalent Jeevamrutha; M_9: 25 % N equivalent FYM + 25 % N equivalent PM + 25 % N equivalent Vermicompost + 25 % N equivalent Jeevamrutha I : *Rabi* - 2022; II: *Rabi* -2023

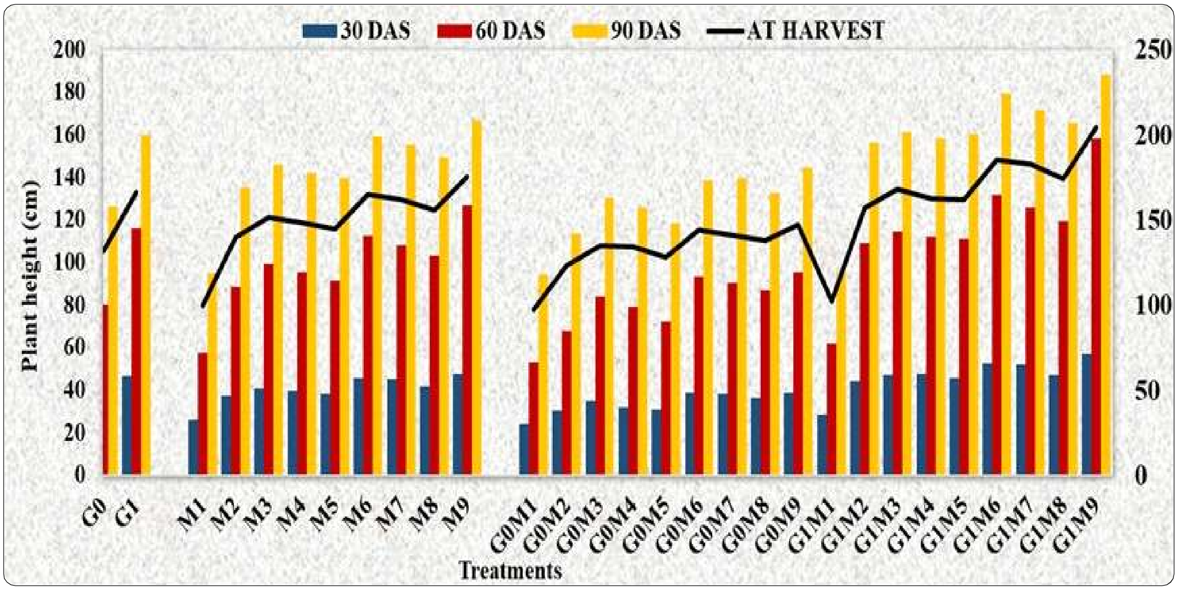

Fig. 1 : Plant height (cm) of maize at different growth stages as influenced by green manuring and different organic sources of nutrients in maize-cowpea cropping sequence (pooled data of two season)

Treatments Details : G_0 : Without Green manure; G_1 : With Green manure; M_1 : No Manure; M_2 : 100 % N equivalent FYM; M_3 : 100 % N equivalent Poultry manure; M_4 : 100 % N equivalent Vermicompost; M_5 : 100 % N equivalent Jeevamrutha; M_6 : 50% N equivalent FYM + 50% N equivalent Poultry manure; M_7 : 50% N equivalent FYM + 50% N equivalent Vermicompost; M_8 : 50 % N equivalent FYM + 50 % N equivalent Jeevamrutha; M_9 : 25 % N equivalent FYM + 25 % N equivalent PM + 25 % N equivalent Vermicompost + 25 % N equivalent Jeevamrutha

FYM + 50% N equivalent vermicompost (G_1M_7) (51.98, 126.0, 171.3 and 182.8 cm at 30, 60, 90 DAS and at harvest, respectively). However, Lower plant height was observed in absolute control plot *i.e.,* without green manure and application of organic sources of nutrient plot (24.08, 52.95, 94.20 and 97.22 cm at 30, 60, 90 DAS and at harvest, respectively).

The significant increase in plant height can be attributed to the rapid decomposition of green manure, which enhances soil organic matter and improves soil structure, particularly in the early stages of growth. This process releases essential nutrients, such as nitrogen, providing maize plants with a continuous and readily available nutrient source during critical growth phases. When combined with the application of various organic sources of nutrients, such as FYM, poultry manure, vermicompost and jeevamrutha, a balanced supply of macronutrients (N, P, K) and micronutrients is ensured throughout the growing period. This not only improves soil health but also enhances root development and overall plant growth, resulting in taller plants. The steady release of nutrients from both green manure and organic manures supports sustained plant growth, leading to a significant increase in plant height. Lower plant height in absolute control plot was due to inability of the soil to supply required quantity of nutrients immediately for the plant growth. Similar results were recorded by Thimma Naik (2006), Saha *et al*. (2007) and Devakumar *et al*. (2011).

Number of Green Leaves Per Plant

The number of green leaves per maize plant varied significantly at 30, 60, 90 DAS and at harvest, as influenced by green manuring and various organic nutrient sources in the maize-cowpea cropping sequence, as shown in Table 3. A higher number of green leaves per plant (5.17, 9.79, 11.58 and 10.73 at 30, 60, 90 DAS and at harvest, respectively) was observed with the *insitu* incorporation of green manure (G_1) compared to the no green manure plot (G_0), which recorded 4.07, 7.03, 8.03 and 7.51 leaves at these stages. Among organic nutrient sources, the combined application of 25% N equivalent FYM + 25% N equivalent poultry manure + 25% N equivalent vermicompost + 25% N equivalent jeevamrutha (M_9) produced significantly more green leaves per plant (5.37, 9.92, 12.22 and 11.06 at 30, 60, 90 DAS and at harvest). followed by the application of 50% N equivalent FYM + 50% N equivalent poultry manure (M_6) (5.24, 9.53, 11.26 and 10.48 at these stages) and 50% N equivalent FYM + 50% N equivalent vermicompost (M_7) (5.11, 9.29, 10.81 and 10.16). The lowest number of green leaves was recorded in control plots without manure (3.06, 5.06, 5.85 and 5.32). Significant interaction effects were observed between *insitu* green manure and the different organic nutrient sources. The highest number of green leaves per plant was recorded with the *insitu* incorporation of green manure combined with the application of 25% N equivalent FYM + 25% N equivalent poultry manure + 25% N equivalent vermicompost + 25% N equivalent jeevamrutha (G_1M_9), which achieved 6.11, 11.09, 14.48 and 13.03 leaves at 30, 60, 90 DAS and harvest, respectively. This was followed by the G_1M_6 treatment (green manure with 50% N equivalent FYM + 50% N equivalent poultry manure) with 5.92, 10.82, 13.43 and 12.31 leaves and the G_1M_7 treatment (green manure with 50% N equivalent FYM + 50% N equivalent vermicompost), which recorded 5.77, 10.76, 12.80 and 12.02 leaves. The lowest number of green leaves was observed in the absolute control plot, which received no green manure or organic nutrients (2.86, 4.99, 5.69 and 4.99). The initial rapid growth of maize plants is largely due to accelerated leaf and stem development, which significantly contributes to greater plant height. The increase in leaf number is closely tied to greater plant height, more branching and the availability of essential nutrients during critical crop growth stages. This nutrient availability is particularly improved by the combined use of green manure and organic sources, which enrich the soil and enhance nutrient access, leading to a higher leaf count per plant. Additionally, the production and efficient movement of photosynthates to sink tissues heavily rely on soil mineral nutrients. Many photosynthetic processes require enzymes and co-enzymes derived from these minerals, particularly nitrogen (N), phosphorus (P) and potassium (K). Nitrogen is especially important, as it forms the backbone of chlorophyll and is essential for synthesizing proteins and nucleic acids, supporting both vegetative and reproductive growth phases in maize. The observed growth variations can be directly linked to rapid cell division and elongation spurred by nitrogen availability, resulting in more green leaves per plant. The results are found to be in accordance with Korai *et al*., 2014 and Rajashree, 2022.

Leaf Area (cm^2 $plant^{-1}$)

Leaf area of maize differed significantly at 30, 60, 90 DAS and at harvest as influenced by green manuring and different organic sources of nutrients in maize-cowpea cropping sequence is presented in (Table 4). Higher Leaf area (1356, 4467. 5548 and 5563 cm^2 $plant^{-1}$ at 30, 60, 90 DAS and at harvest, respectively) was observed with the *insitu* incorporation of green manure (G_1) than the no green manure(G_0) incorporation plot (959, 3314, 4283 and 4161 cm^2 $plant^{-1}$ at 30, 60, 90 DAS and at harvest, respectively). Among organic sources of nutrient combined application of different organic sources of nutrients *i.e* 25 % N equivalent FYM + 25 % N equivalent poultry manure + 25 % N equivalent vermicompost + 25 % N equivalent jeevamrutha (M_9) recorded significantly higher leaf area (1419, 4560, 5841 and 6034 cm^2 $plant^{-1}$ at 30, 60, 90 DAS and at harvest, respectively), followed by application of 50% N equivalent FYM + 50% N equivalent poultry manure (M_6) (1348, 4414, 5630 and 5600 cm^2 $plant^{-1}$ at 30, 60, 90 DAS and at harvest, respectively) and application of 50% N equivalent FYM + 50% N equivalent Vermicompost (M_7) (1289, 4304, 5441 and 5518 cm^2 $plant^{-1}$ at 30, 60, 90 DAS and at harvest, respectively) and lower Leaf area was recorded in no manure (Control) plots (3.06, 5.06, 5.85 and 5.32 at 30, 60, 90 DAS and at harvest, respectively). Among the interaction of *insitu* green manure and different organic sources of nutrients was found to be significant.

In situ incorporation of green manure *fb* combined application of different organic sources of nutrients

Table 3

Number of green leaves per plant of maize at different growth stages as influenced by green manuring and different organic sources of nutrients in maize-cowpea cropping sequence

Treatment	30 DAYS			60 DAYS			90 DAYS			AT Harvest		
	I	II	Pooled	I	II	Pooled	I	II	Pooled	II	II	Pooled
G_0	3.91	4.23	4.07	6.57	7.50	7.03	7.86	8.19	8.03	7.35	7.66	7.51
G_1	4.96	5.38	5.17	9.51	10.08	9.79	11.08	12.07	11.58	10.31	11.16	10.73
F test *	*	*	*	*	*	*	*	*	*	*	*	
S. Em ±	0.08	0.09	0.08	0.15	0.16	0.15	0.18	0.35	0.26	0.25	0.29	0.27
C.D. (p=0.05)	0.23	0.25	0.24	0.42	0.52	0.46	1.09	2.15	0.79	0.74	0.88	0.80
M_1	2.91	3.20	3.06	4.92	5.20	5.06	5.74	5.96	5.85	5.28	5.36	5.32
M_2	4.00	4.32	4.16	7.17	7.90	7.53	8.48	9.06	8.77	7.99	8.43	8.21
M_3	4.61	4.94	4.77	8.36	9.12	8.74	9.97	10.15	10.06	9.16	9.65	9.40
M_4	4.35	4.83	4.59	7.99	8.93	8.46	9.62	9.95	9.78	8.79	9.09	8.94
M_5	4.22	4.54	4.38	7.60	8.69	8.15	8.88	9.43	9.15	8.46	8.97	8.71
M_6	5.04	5.44	5.24	9.22	9.84	9.53	10.57	11.95	11.26	10.06	10.89	10.48
M_7	4.92	5.30	5.11	8.93	9.64	9.29	10.39	11.23	10.81	9.73	10.60	10.16
M_8	4.70	5.13	4.91	8.67	9.42	9.05	10.26	10.37	10.31	9.48	10.10	9.79
M_9	5.18	5.55	5.37	9.48	10.35	9.92	11.31	13.12	12.22	10.53	11.60	11.06
F test *	*	*	*	*	*	*	*	*	*	*	*	
S. Em ±	0.10	0.14	0.12	0.40	0.40	0.40	0.41	0.57	0.49	0.42	0.44	0.43
C.D. (p=0.05)	0.29	0.41	0.34	1.15	1.15	1.19	1.19	1.63	1.46	1.22	1.27	1.25
G_0M_1	2.65	3.07	2.86	4.80	5.18	4.99	5.59	5.78	5.69	4.80	5.17	4.99
G_0M_2	3.45	3.42	3.44	5.71	5.57	5.64	6.69	7.17	6.93	6.14	7.00	6.57
G_0M_3	4.14	4.48	4.31	6.63	7.49	7.06	8.07	8.46	8.27	7.49	7.73	7.61
G_0M_4	3.99	4.46	4.22	6.18	7.26	6.72	7.29	8.24	7.76	6.77	7.06	6.91
G_0M_5	3.78	3.87	3.83	5.93	7.22	6.58	6.76	7.48	7.12	6.43	7.06	6.74
G_0M_6	4.37	4.75	4.56	7.52	8.82	8.17	8.90	9.29	9.09	8.45	8.82	8.64
G_0M_7	4.24	4.68	4.46	7.09	8.46	7.77	8.63	9.00	8.82	7.91	8.71	8.31
G_0M_8	4.16	4.54	4.35	6.76	8.02	7.39	8.48	8.75	8.62	7.84	8.60	8.22
G_0M_9	4.42	4.82	4.62	8.26	9.44	8.85	10.32	9.58	9.95	9.38	8.82	9.10
G_1M_1	3.17	3.33	3.25	5.05	5.22	5.13	5.89	6.13	6.01	5.76	5.55	5.65
G_1M_2	4.55	5.21	4.88	8.63	10.22	9.43	10.27	10.95	10.61	9.83	9.86	9.84
G_1M_3	5.09	5.39	5.24	10.09	10.76	10.42	11.87	11.84	11.85	10.82	11.58	11.20
G_1M_4	4.71	5.21	4.96	9.79	10.60	10.20	11.94	11.66	11.80	10.80	11.12	10.96
G_1M_5	4.66	5.21	4.94	9.27	10.16	9.72	11.00	11.39	11.19	10.49	10.89	10.69
G_1M_6	5.71	6.13	5.92	10.78	10.86	10.82	12.25	14.61	13.43	11.68	12.95	12.31
G_1M_7	5.61	5.92	5.77	10.70	10.82	10.76	12.15	13.45	12.80	11.55	12.48	12.02
G_1M_8	5.23	5.71	5.47	10.58	10.83	10.70	12.03	11.98	12.01	11.12	11.61	11.36
G_1M_9	5.94	6.29	6.11	10.92	11.25	11.09	12.30	16.65	14.48	11.68	14.37	13.03
F test	*	*	*	*	*	*	*	*	*	*	*	*
S. Em ±	0.14	0.20	0.17	0.56	0.57	0.56	0.59	0.80	0.69	0.60	0.62	0.61
C.D. (p=0.05)	0.41	0.58	0.48	1.62	1.63	1.68	1.69	2.31	1.38	1.72	1.79	1.82

Note : G_0: Without Green manure; G_1: With Green manure ; M_1: No Manure ; M_2: 100 % N equivalent FYM; M_3: 100 % N equivalent Poultry manure; M_4: 100 % N equivalent Vermicompost; M_5: 100 % N equivalent Jeevamrutha; M_6: 50% N equivalent FYM + 50% N equivalent Poultry manure; M_7: 50% N equivalent FYM + 50% N equivalent Vermicompost; M_8: 50 % N equivalent FYM + 50 % N equivalent Jeevamrutha; M_9: 25 % N equivalent FYM + 25 % N equivalent PM + 25 % N equivalent Vermicompost + 25 % N equivalent Jeevamrutha I: *Rabi* -2022; II: *Rabi* -2023.

TABLE 4

Leaf area (cm² plant⁻¹) of maize at different growth stages as influenced by green manuring and different organic sources of nutrients in maize-cowpea cropping sequence

Treatment	30 DAYS			60 DAYS			90 DAYS			AT Harvest		
	I	II	Pooled	I	II	Pooled	I	II	Pooled	I	II	Pooled
G_0	927	990	959	3191	3437	3314	4161	4405	4283	4030	4291	4161
G_1	1304	1407	1356	4303	4631	4467	5315	5782	5548	5441	5685	5563
F test *	*	*	*	*	*	*	*	*	*	*	*	
S. Em ±	34.56	35.95	35.25	54.8	56.73	55.76	91.70	93.36	92.53	185.6	191.2	188.4
C.D. (p=0.05)	103.7	107.9	103.6	164.2	170.1	167.1	273.1	278.8	275.6	546.8	564.4	558.2
M_1	749	794	771	2226	2579	2403	2706	3069	2888	2564	2696	2630
M_2	996	1090	1043	3433	3638	3535	4479	4608	4543	4105	4369	4237
M_3	1134	1190	1162	3844	4170	4007	4906	5252	5079	4863	5112	4988
M_4	1072	1149	1110	3743	4001	3872	4741	5020	4880	4614	5016	4815
M_5	1011	1109	1060	3644	3856	3750	4598	4733	4665	4526	4682	4604
M_6	1302	1394	1348	4253	4575	4414	5372	5888	5630	5413	5787	5600
M_7	1237	1342	1289	4147	4460	4304	5180	5703	5441	5374	5662	5518
M_8	1177	1245	1211	4033	4309	4171	5097	5445	5271	5226	5435	5330
M_9	1363	1476	1419	4400	4720	4560	5561	6122	5841	5935	6134	6034
F test *	*	*	*	*	*	*	*	*	*	*	*	
S. Em ±	47.90	52.91	50.4	136.0	136.5	136.2	126.7	133.5	130.1	187.3	191.5	189.2
C.D. (p=0.05)	137.97	152.4	151.2	390.2	393.1	392.5	363.45	384.7	380.3	541.5	551.7	545.2
G_0M_1	743	772	757	2220	2465	2342	2567	2904	2735	2534	2663	2599
G_0M_2	810	889	849	2826	3091	2958	3640	3874	3757	3125	3386	3256
G_0M_3	943	1009	976	3326	3529	3427	4206	4613	4410	4343	4553	4448
G_0M_4	896	928	912	3128	3409	3269	4088	4349	4219	3961	4420	4190
G_0M_5	828	890	859	3101	3409	3255	3860	3966	3913	3837	3991	3914
G_0M_6	1038	1116	1077	3624	3836	3730	4779	5000	4890	4593	4981	4787
G_0M_7	984	1078	1031	3491	3629	3560	4643	4952	4798	4520	4939	4730
G_0M_8	983	1072	1028	3328	3609	3469	4598	4725	4662	4452	4661	4557
G_0M_9	1120	1160	1140	3678	3958	3818	5063	5259	5161	4909	5025	4967
G_1M_1	755	816	785	2233	2693	2463	2845	3235	3040	2593	2729	2661
G_1M_2	1182	1292	1237	4041	4184	4113	5317	5342	5329	5085	5353	5219
G_1M_3	1326	1372	1349	4362	4811	4586	5596	5892	5744	5383	5672	5527
G_1M_4	1249	1369	1309	4358	4594	4476	5393	5690	5542	5268	5612	5440
G_1M_5	1193	1328	1261	4187	4303	4245	5336	5500	5418	5214	5373	5293
G_1M_6	1566	1673	1619	4882	5313	5098	5965	6776	6371	6233	6593	6413
G_1M_7	1489	1607	1548	4803	5291	5047	5716	6453	6085	6228	6385	6306
G_1M_8	1371	1418	1395	4738	5008	4873	5605	6166	5885	6000	6208	6104
G_1M_9	1605	1791	1698	5123	5482	5303	5315	5782	5548	6961	7243	7102
F test	*	*	*	*	*	*	*	*	*	*	*	*
S. Em ±	67.7	74.8	71.25	192.4	193.1	192.7	178.4	188.8	183.6	265.9	270.9	268.4
C.D. (p=0.05)	195.1	215.5	213.3	552.2	559.3	385.4	514.0	544.0	530.3	765.8	780.4	772.9

Note : G_0: Without Green manure; G_1: With Green manure ; M_1: No Manure ; M_2: 100 % N equivalent FYM; M_3: 100 % N equivalent Poultry manure; M_4: 100 % N equivalent Vermicompost; M_5: 100 % N equivalent Jeevamrutha; M_6: 50% N equivalent FYM + 50% N equivalent Poultry manure; M_7: 50% N equivalent FYM + 50% N equivalent Vermicompost; M_8: 50 % N equivalent FYM + 50 % N equivalent Jeevamrutha; M_9: 25 % N equivalent FYM + 25 % N equivalent PM + 25 % N equivalent Vermicompost + 25 % N equivalent Jeevamrutha I: *Rabi* -2022; II: *Rabi* -2023

i.e. 25 % N equivalent FYM + 25 % N equivalent poultry manure + 25 % N equivalent vermicompost + 25 % N equivalent jeevamrutha (G_1M_9) recorded higher Leaf area (1698, 5303, 5548 and 7102 cm^2 $plant^{-1}$ at 30, 60, 90 DAS and at harvest, respectively) followed by treatment (G_1M_6) i.e., *insitu* incorporation of green manure *fb* combined application of 50 % N equivalent FYM + 50% N equivalent poultry manure (1619, 5098, 6371 and 6413 cm^2 $plant^{-1}$ cm^2 $plant^{-1}$ at 30, 60, 90 DAS and at harvest, respectively) and 50 % N equivalent FYM + 50% N equivalent vermicompost (G_1M_7) (1548, 5047, 6085 and 6306 cm^2 $plant^{-1}$ at 30, 60, 90 DAS and at harvest, respectively). However, Lower leaf area was observed in absolute control plot *i.e.,* without green manure and application of organic sources of nutrient plot (757, 2342, 2735 and 2599 cm^2 $plant^{-1}$ at 30, 60, 90 DAS and at harvest, respectively).

Increased availability of nutrients in soil due to mineralization of organic nutrient sources could have triggered cell elongation and multiplication resulting in high growth rate of shoot in turn increase in leaf area of maize as compared to control. These results are in line with the outcomes of Ashwini *et al.,* 2015.

Total Dry Matter Accumulation (g $plant^{-1}$)

Significantly higher total dry matter accumulation of maize was recorded with the application of green manuring. Different organic sources of nutrients in maize-cowpea cropping sequence is presented in (Table 5 and Fig. 2). Higher dry matter production (8.99, 60.49. 103.0 and 119.6 g $plant^{-1}$ at 30, 60, 90 DAS and at harvest, respectively) was observed with the *insitu* incorporation of green manure (G_1) than the no green manure (G_0) incorporation plot (6.94, 42.63, 78.54 and 86.4 g $plant^{-1}$ at 30, 60, 90 DAS and at harvest, respectively). Among organic sources of nutrient combined application of different organic sources of nutrients *i.e* 25 % N equivalent FYM + 25 % N equivalent poultry manure + 25 % N equivalent vermicompost + 25 % N equivalent jeevamrutha (M_9) recorded significantly higher dry matter production (9.62, 62.25, 108.5 and 130.1 g $plant^{-1}$ at 30, 60, 90 DAS and at harvest, respectively), followed by application of 50 % N equivalent FYM + 50% N equivalent poultry manure (M_6) (9.13, 58.28, 104.6 and 119.6 g $plant^{-1}$ at 30, 60, 90 DAS and at harvest, respectively) and application of 50% N equivalent FYM + 50% N equivalent vermicompost (M_7) (8.72, 56.99, 100.4 and 115.0 g $plant^{-1}$ at 30, 60, 90 DAS and at harvest, respectively) and lower dry matter production was recorded in no manure (Control) plots (5.54, 33.0, 57.35 and 66.6 g $plant^{-1}$ at 30, 60, 90 DAS and at harvest, respectively). Among the interaction of *insitu* green manure and different organic sources of nutrients was found to be significant.

Insitu incorporation of green manure *fb* combined application of different organic sources of nutrients *i.e.* 25 % N equivalent FYM + 25 % N equivalent poultry manure + 25 % N equivalent vermicompost + 25 % N equivalent jeevamrutha (G_1M_9) recorded higher dry matter production (11.20, 74.11, 130.5 and 163.4 g $plant^{-1}$ at 30, 60, 90 DAS and at harvest, respectively) followed by treatment (G_1M_6) *i.e., insitu* incorporation of green manure *fb* combined application of 50 % N equivalent FYM + 50 % N equivalent poultry manure (10.39, 67.23, 123.0 and 141.8 g $plant^{-1}$ at 30, 60, 90 DAS and at harvest, respectively) and 50 % N equivalent FYM + 50 % N equivalent vermicompost (G_1M_7) (9.81, 68.67, 114.9 and 135.3 g $plant^{-1}$ at 30, 60, 90 DAS and at harvest, respectively). However, Dry matter production (g $plant^{-1}$) was observed in absolute control plot *i.e.,* without green manure and application of organic sources of nutrient plot (5.25, 32.08, 55.16 and 65.41 g $plant^{-1}$ at 30, 60, 90 DAS and at harvest, respectively). Total dry matter production is a result of dry matter accumulation in plant parts, which depends on uptake of nutrients like N, P and K. Increase in dry matter was mainly due to increase in number of leaves produced per plant and better uptake of nutrients. Application of green manures and different organic sources of nutrients has increased biological efficiency and greater sink capacity in the crop which might have helped in higher photosynthetic efficiency and absorption of nutrients. Similar results are being observed by Roopashree *et al.*, 2019 and Vighnesh (2023).

TABLE 5

Total dry matter accumulation (g plant^{-1}) of maize at different growth stages as influenced by green manuring and different organic sources of nutrients in maize-cowpea cropping sequence

Treatment	30 DAYS			60 DAYS			90 DAYS			AT Harvest		
	I	II	Pooled	I	II	Pooled	I	II	Pooled	II	II	Pooled
G_0	6.78	7.10	6.94	40.51	44.74	42.63	76.46	80.61	78.54	80.91	91.97	86.4
G_1	8.89	9.09	8.99	60.25	60.73	60.49	101.1	104.9	103.0	114.9	124.3	119.6
F test	*	*	*	*	*	*	*	*	*	*	*	*
S. Em ±	0.13	0.16	0.14	1.11	1.23	1.17	2.77	3.35	3.06	4.53	4.90	4.71
C.D. (p=0.05)	0.43	0.52	0.44	3.22	3.51	3.47	8.23	9.91	9.21	13.32	14.21	13.6
M_1	5.48	5.60	5.54	32.79	33.21	33.00	53.21	61.49	57.35	60.53	72.61	66.6
M_2	7.12	7.42	7.27	46.81	46.87	46.84	79.97	84.12	82.05	84.23	96.80	90.5
M_3	7.93	8.13	8.03	52.10	54.47	53.29	91.82	95.29	93.56	96.92	106.4	101.7
M_4	7.48	7.83	7.66	49.85	51.19	50.52	87.72	90.15	88.93	92.77	102.6	97.7
M_5	7.28	7.56	7.42	47.22	49.65	48.43	83.79	87.10	85.45	89.40	101.0	95.2
M_6	9.05	9.21	9.13	58.49	58.07	58.28	102.6	106.6	104.6	114.6	124.5	119.6
M_7	8.59	8.86	8.72	55.44	58.54	56.99	99.12	101.6	100.4	111.0	119.1	115.0
M_8	8.13	8.47	8.30	53.48	55.39	54.44	94.42	98.12	96.27	106.7	114.7	110.7
M_9	9.45	9.78	9.62	59.42	65.07	62.25	106.2	110.7	108.5	125.0	135.2	130.1
F test	*	*	*	*	*	*	*	*	*	*	*	*
S. Em ±	0.21	0.22	0.21	2.13	2.19	2.16	3.64	3.90	3.77	5.72	6.30	6.01
C.D. (p=0.05)	0.62	0.65	0.63	6.12	6.27	6.04	10.26	10.92	10.55	17.16	18.14	18.02
G_0M_1	5.24	5.26	5.25	31.30	32.86	32.08	51.20	59.12	55.16	57.18	73.65	65.41
G_0M_2	5.98	6.48	6.23	37.44	36.64	37.04	68.58	75.42	72.00	68.57	85.36	76.97
G_0M_3	6.89	7.23	7.06	40.93	46.76	43.85	79.96	83.31	81.63	83.79	93.75	88.77
G_0M_4	6.33	6.89	6.61	37.75	43.51	40.63	76.45	81.61	79.03	78.54	91.07	84.81
G_0M_5	6.18	6.57	6.37	37.93	41.02	39.48	73.57	79.31	76.44	74.79	89.30	82.04
G_0M_6	7.82	7.93	7.87	46.94	51.71	49.32	84.80	87.52	86.16	93.15	101.5	97.32
G_0M_7	7.42	7.86	7.64	42.16	48.46	45.31	86.03	85.47	85.75	90.64	98.84	94.74
G_0M_8	7.31	7.56	7.43	42.19	48.94	45.57	82.71	85.80	84.25	87.65	94.44	91.04
G_0M_9	7.91	8.15	8.03	47.99	52.77	50.38	84.84	87.97	86.41	93.88	99.84	96.86
G_1M_1	5.72	5.94	5.83	34.27	33.57	33.92	55.22	63.86	59.54	63.87	71.57	67.72
G_1M_2	8.27	8.36	8.31	56.18	57.10	56.64	91.35	92.83	92.09	99.90	108.2	104.0
G_1M_3	8.98	9.03	9.01	63.27	62.18	62.72	103.6	107.3	105.5	110.1	119.2	114.6
G_1M_4	8.64	8.77	8.71	61.94	58.86	60.40	98.9	98.6	98.8	107.0	114.2	110.6
G_1M_5	8.39	8.56	8.47	56.51	58.27	57.39	94.0	94.9	94.5	104.0	112.8	108.4
G_1M_6	10.2	10.48	10.39	70.04	64.43	67.23	120.4	125.6	123.0	136.0	147.6	141.8
G_1M_7	9.75	9.87	9.81	68.71	68.63	68.67	112.2	117.8	114.9	131.4	139.3	135.3
G_1M_8	8.96	9.37	9.16	64.76	61.85	63.30	106.1	110.4	108.3	125.8	135.0	130.4
G_1M_9	10.9	11.42	11.20	70.86	77.37	74.11	127.6	133.4	130.5	156.1	170.6	163.4
F test	*	*	*	*	*	*	*	*	*	*	*	*
S. Em ±	0.30	0.32	0.31	3.08	3.01	3.04	4.72	5.52	5.12	6.68	8.90	7.79
C.D. (p=0.05)	0.88	0.95	0.92	8.87	8.66	9.02	13.61	15.89	15.26	19.24	25.65	21.06

Note : G_0: Without Green manure; G_1: With Green manure ; M_1: No Manure ; M_2: 100 % N equivalent FYM; M_3: 100 % N equivalent Poultry manure; M_4: 100 % N equivalent Vermicompost; M_5: 100 % N equivalent Jeevamrutha; M_6: 50% N equivalent FYM + 50% N equivalent Poultry manure; M_7: 50% N equivalent FYM + 50% N equivalent Vermicompost; M_8: 50 % N equivalent FYM + 50 % N equivalent Jeevamrutha; M_9: 25 % N equivalent FYM + 25 % N equivalent PM + 25 % N equivalent Vermicompost + 25 % N equivalent Jeevamrutha I: *Rabi* -2022; II: *Rabi* -2023

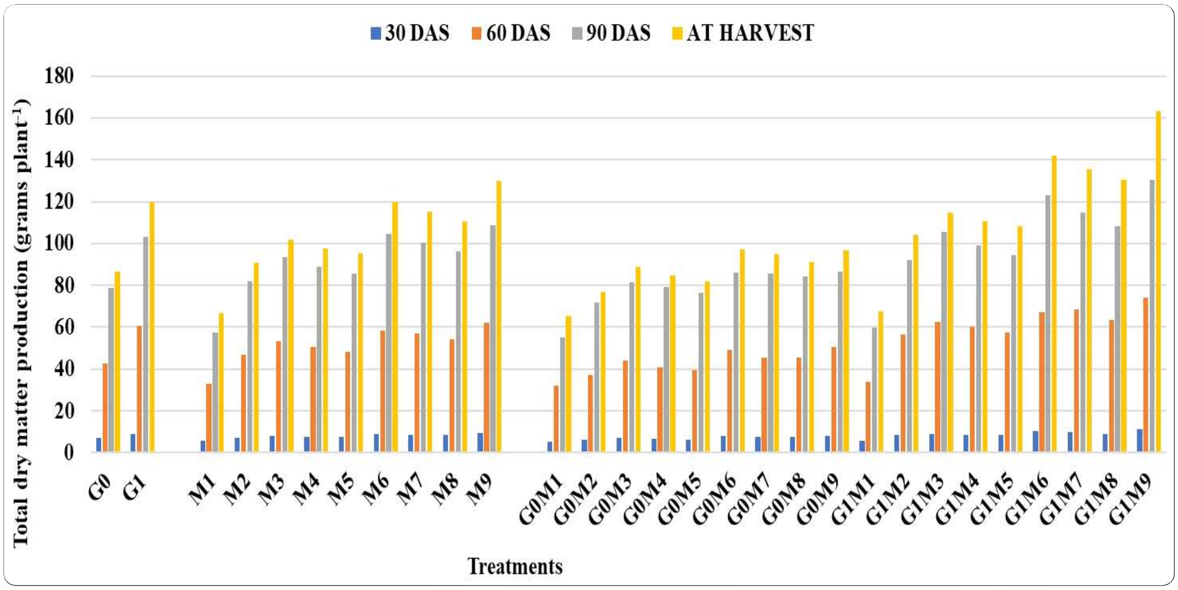

Fig. 2 : Total dry matter accumulation (g) of maize at different growth stages as influenced by green manuring and different organic sources of nutrients in maize-cowpea cropping sequence (pooled data of two season)

Treatments Details : G_0 : Without Green manure; G_1 : With Green manure; M_0 : No Manure; M_1 : 100 % N equivalent FYM; M_2 : 100 % N equivalent Poultry manure; M_3 : 100 % N equivalent Vermicompost; M_4 : 100 % N equivalent Jeevamrutha; M_5 : 50% N equivalent FYM + 50% N equivalent Poultry manure; M_6 : 50% N equivalent FYM + 50% N equivalent Vermicompost; M_7 : 50 % N equivalent FYM + 50 % N equivalent Jeevamrutha; M_8 : 25 % N equivalent FYM + 25 % N equivalent PM + 25 % N equivalent Vermicompost + 25 % N equivalent Jeevamrutha

Kernel Yield (q ha^{-1}), Stover Yield (q ha^{-1}) and Harvest Index of Maize

Kernel and stover yield of maize (Table 6 and Fig. 3) differed significantly due to as influenced by green manuring and different organic sources of nutrients in maize-cowpea cropping sequence. Significantly higher kernel and stover yield of maize were recorded with the application of green manure (G_1) incorporation (76.38 and 100.6 q ha^{-1}, respectively) than the no green manure (G_0) incorporation plot (59.67 and 84.66 q ha^{-1}, respectively).

The data on number of kernel and stover yield of maize varied significantly due to application of organic sources. Among organic sources of nutrient combined application of different organic sources of nutrients *i.e.,* 25% N equivalent FYM + 25% N equivalent poultry manure + 25% N equivalent vermicompost + 25% N equivalent jeevamrutha (M_9) recorded significantly higher significantly kernel and stover yield of maize (79.55 and 107.6 q ha^{-1}, respectively) followed by application of 50% N equivalent FYM + 50% N equivalent poultry manure (M_6) (74.50 and 97.70 q ha^{-1}, respectively) and application of 50% N equivalent FYM + 50% N equivalent vermicompost (M_7) (72.18 and 96.58 q ha^{-1}, respectively) and lower kernel and stover yield of maize were recorded in no manure (Control) plots (49.29 and 76.03 q ha^{-1}, respectively).

Kernel and stover yield of maize were found to be significant for the interaction between green manuring and different organic sources. *In situ* incorporation of green manure *fb* combined application of different organic sources of nutrients *i.e.* 25% N equivalent FYM + 25% N equivalent poultry manure + 25% N equivalent vermicompost + 25% N equivalent jeevamrutha (G_1M_9) recorded significantly higher kernel and stover yield of maize (91.67 and 125.4 q ha^{-1}, respectively) followed by treatment (G_1M_6) *i.e., in situ* incorporation of green manure *fb* combined application of 50% N equivalent FYM + 50% N equivalent poultry manure (82.20 and 105.6 q ha^{-1}, respectively) and 50% N equivalent FYM + 50% N

TABLE 6

Kernel yield, stover yield and harvest index of maize as influenced by green manuring and different organic sources of nutrients in maize-cowpea cropping sequence

Treatments	Kernel yield			Stover yield			Harvest index		
	I	II	Mean	I	II	Mean	I	II	Mean
G_0	57.29	62.05	59.67	85.89	83.44	84.66	0.40	0.43	0.41
G_1	74.71	78.06	76.38	101.4	99.90	100.6	0.42	0.44	0.43
F test	*	*	*	*	*	*	NS	NS	NS
S. Em ±	1.74	1.82	1.78	1.58	1.33	1.45	-	-	-
C.D. (p=0.05)	5.13	5.39	5.26	4.69	3.87	4.27	-	-	-
M_1	46.56	52.02	49.29	78.68	73.38	76.03	0.37	0.41	0.39
M_2	60.84	67.80	64.32	90.08	86.08	88.08	0.40	0.44	0.42
M_3	67.05	71.27	69.16	93.44	91.85	92.64	0.42	0.44	0.43
M_4	64.93	70.19	67.56	92.03	90.32	91.18	0.41	0.44	0.43
M_5	62.67	65.52	64.10	91.05	88.59	89.82	0.41	0.43	0.42
M_6	73.33	75.67	74.50	98.59	96.80	97.70	0.43	0.44	0.43
M_7	71.16	73.19	72.18	97.66	95.50	96.58	0.42	0.43	0.43
M_8	68.86	74.35	71.60	94.21	94.43	94.32	0.42	0.44	0.43
M_9	78.58	80.51	79.55	107.1	108.0	107.63	0.42	0.43	0.42
F test	*	*	*	*	*	*	NS	NS	NS
S. Em ±	1.93	2.67	2.30	2.45	3.18	2.80	-	-	-
C.D. (p=0.05)	5.56	7.69	6.70	6.98	9.15	8.41	-	-	-
G_0M_1	45.47	50.54	48.01	77.89	70.83	74.36	0.37	0.42	0.39
G_0M_2	47.95	59.60	53.78	82.68	82.71	82.69	0.37	0.42	0.39
G_0M_3	58.50	63.10	60.80	84.38	84.05	84.21	0.41	0.43	0.42
G_0M_4	53.67	63.09	58.38	84.43	83.22	83.82	0.39	0.43	0.41
G_0M_5	48.97	53.87	51.42	83.79	82.76	83.27	0.37	0.39	0.38
G_0M_6	66.80	66.81	66.80	92.33	87.17	89.75	0.42	0.43	0.43
G_0M_7	66.40	64.66	65.53	90.92	87.01	88.97	0.42	0.43	0.42
G_0M_8	61.69	68.11	64.90	85.17	85.04	85.10	0.42	0.44	0.43
G_0M_9	66.15	68.71	67.43	91.46	88.14	89.80	0.42	0.44	0.43
G_1M_1	47.65	53.49	50.57	79.47	75.93	77.70	0.37	0.41	0.39
G_1M_2	73.72	76.00	74.86	97.49	89.45	93.47	0.43	0.46	0.44
G_1M_3	75.60	79.45	77.52	102.50	99.64	101.07	0.42	0.44	0.43
G_1M_4	76.19	77.29	76.74	99.64	97.42	98.53	0.43	0.44	0.44
G_1M_5	76.37	77.16	76.77	98.32	94.41	96.36	0.44	0.45	0.44
G_1M_6	79.85	84.54	82.20	104.8	106.42	105.6	0.43	0.44	0.44
G_1M_7	75.92	81.72	78.82	104.4	104.0	104.2	0.42	0.44	0.43
G_1M_8	76.03	80.59	78.31	103.2	103.8	103.5	0.42	0.44	0.43
G_1M_9	91.02	92.32	91.67	122.9	128.0	125.4	0.43	0.42	0.42
F test	*	*	*	*	*	*	NS	NS	NS
S. Em ±	2.73	3.77	3.25	3.43	4.49	3.96	-	-	-
C.D. (p=0.05)	8.02	11.10	9.57	9.88	12.94	11.59	-	-	-

Note : G_0: Without Green manure; G_1: With Green manure ; M_1: No Manure ; M_2: 100 % N equivalent FYM; M_3: 100 % N equivalent Poultry manure; M_4: 100 % N equivalent Vermicompost; M_5: 100 % N equivalent Jeevamrutha; M_6: 50% N equivalent FYM + 50% N equivalent Poultry manure; M_7: 50% N equivalent FYM + 50% N equivalent Vermicompost; M_8: 50 % N equivalent FYM + 50 % N equivalent Jeevamrutha; M_9: 25 % N equivalent FYM + 25 % N equivalent PM + 25 % N equivalent Vermicompost + 25 % N equivalent Jeevamrutha I: *Rabi* -2022; II: *Rabi* -2023

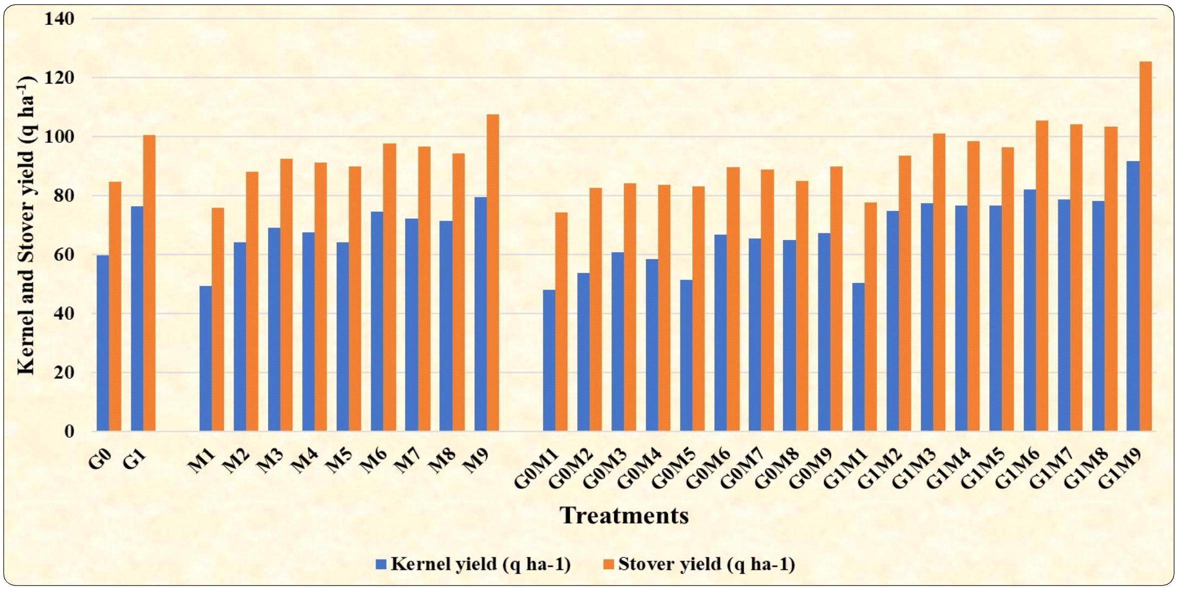

Fig. 3 : Kernel and stover yield (q ha^{-1}) of maize as influenced by green manuring and different organic sources of nutrients in maize-cowpea cropping sequence (pooled data of two season)

Treatments Details : G_0 : Without Green manure; G_1 : With Green manure; M_1 : No Manure; M_2 : 100 % N equivalent FYM; M_3 : 100 % N equivalent Poultry manure; M_4 : 100 % N equivalent Vermicompost; M_5 : 100 % N equivalent Jeevamrutha; M_6 : 50% N equivalent FYM + 50% N equivalent Poultry manure; M_7 : 50% N equivalent FYM + 50% N equivalent Vermicompost; M_8 : 50 % N equivalent FYM + 50 % N equivalent Jeevamrutha; M_9 : 25 % N equivalent FYM + 25 % N equivalent PM + 25 % N equivalent Vermicompost + 25 % N equivalent Jeevamrutha

TABLE 7

Economics of maize as influenced by green manuring and different organic sources of nutrients in maize-cowpea cropping sequence

Treatment	Cost of cultivation (Rs. ha^{-1})			Gross returns (Rs. ha^{-1})			Net returns (Rs. ha^{-1})			B:C ratio (Rs. ha^{-1})		
	I	II	Pooled	I	II	Pooled	I	II	Pooled	I	II	Pooled
G_0M_1	62635	62815	62725	112370	123325	117848	49735	60510	55123	1.79	1.96	1.88
G_0M_2	69635	69815	69725	118553	145351	131952	48918	75536	62227	1.70	2.08	1.89
G_0M_3	59635	59815	59725	142988	153535	148262	83353	93720	88537	2.40	2.57	2.48
G_0M_4	84635	84815	84725	131884	153429	142657	47249	68614	57932	1.56	1.81	1.68
G_0M_5	59635	59815	59725	121010	132177	126594	61375	72362	66869	2.03	2.21	2.12
G_0M_6	64635	64815	64725	162873	162380	162627	98238	97565	97902	2.52	2.51	2.51
G_0M_7	79635	79815	79725	161812	157419	159616	82177	77604	79891	2.03	1.97	2.00
G_0M_8	62135	62315	62225	150404	165157	157781	88269	102842	95556	2.42	2.65	2.54
G_0M_9	70260	70440	70350	161291	166847	164069	91031	96407	93719	2.30	2.37	2.33
G_1M_1	62935	63115	63025	117542	130620	124081	54607	67505	61056	1.87	2.07	1.97
G_1M_2	73935	74115	74025	179305	183745	181525	105370	109630	107500	2.43	2.48	2.45
G_1M_3	63935	64115	64025	184130	192699	188415	120195	128584	124390	2.88	3.01	2.94
G_1M_4	88935	89115	89025	185201	187509	186355	96266	98394	97330	2.08	2.10	2.09
G_1M_5	63935	64115	64025	185483	186909	186196	121548	122794	122171	2.90	2.92	2.91

Continued....

TABLE 7 Continued....

Treatment	Cost of cultivation (Rs. ha-1)			Gross returns (Rs. ha-1)			Net returns (Rs. ha-1)			B:C ratio (Rs. ha-1)		
	I	II	Pooled	I	II	Pooled	I	II	Pooled	I	II	Pooled
G_1M_6	68935	69115	69025	194141	205084	199613	125206	135969	130588	2.82	2.97	2.89
G_1M_7	83935	84115	84025	185056	198356	191706	101121	114241	107681	2.20	2.36	2.28
G_1M_8	65185	65365	65275	185194	195737	190466	120009	130372	125191	2.84	2.99	2.92
G_1M_9	72060	72240	72150	221636	225136	223386	149576	152896	151236	3.08	3.12	3.10

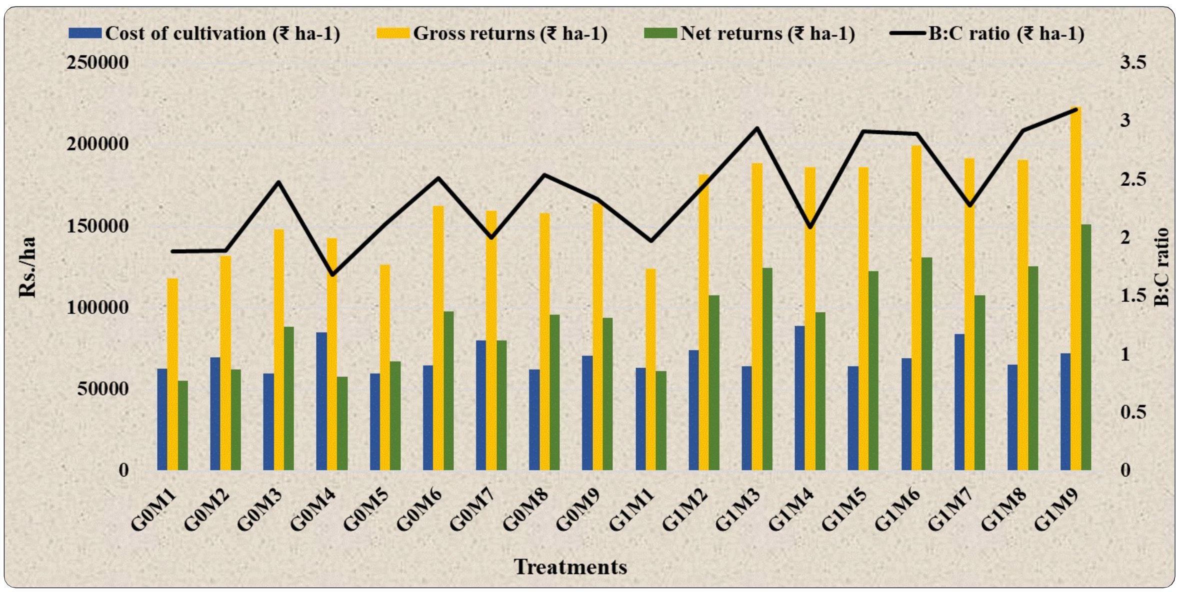

Fig. 4 : Economics of maize as influenced by green manuring and different organic sources of nutrients in maize-cowpea cropping sequence (pooled data of two season)

Treatments Details : G_0: Without Green manure; G_1: With Green manure; M_1: No Manure; M_2: 100% N equivalent FYM; M_3: 100% N equivalent Poultry manure; M_4: 100% N equivalent Vermicompost; M_5: 100% N equivalent Jeevamrutha; M_6: 50% N equivalent FYM + 50% N equivalent Poultry manure; M_7: 50% N equivalent FYM + 50% N equivalent Vermicompost; M_8: 50% N equivalent FYM + 50% N equivalent Jeevamrutha; M_9: 25% N equivalent FYM + 25% N equivalent PM + 25% N equivalent Vermicompost + 25% N equivalent Jeevamrutha

equivalent vermicompost (G_1M_7) 78.82 and 104.2 q ha^{-1}, respectively). However, significantly lowest kernel and stover yield of maize were observed in absolute control plot *i.e.,* without green manure and application of organic sources of nutrient plot (48.01 and 74.36 q ha^{-1}, respectively). The results are in line with the findings of Ananda and Sharanappa (2017) and Prajwal Kumar *et al*., 2021. The increase in the yield primarily due to enhanced yield parameters, such as the number of kernel rows, kernels per row and test weight. The combined application of manures and jeevamrutha ensures the availability of readily accessible nutrients in sufficient quantities, promoting early plant growth. This contrasts with sole organic manuring treatments, where nutrient release is slower and more prolonged. The improved growth and yield parameters can be attributed to the macronutrients and micronutrients supplied by organic manure, which are crucial for plant growth and development (Boraiah *et al*., 2017). On the other hand, lower grain yields may result from limited nutrient availability during the crop's early vegetative growth stages, potentially causing nutrient deficiencies during the reproductive stage and negatively impacting grain and stover yields (Urkurkar *et al*., 2010). The observed increase in green fodder yield is linked to factors such as greater plant height, a higher number of leaves, increased leaf area, a higher leaf area index and total dry matter production. The correlation between leaf area and fodder yield underscores its role as an indicator of assimilatory surface area, facilitating the synthesis and accumulation of photosynthates and dry matter, as also noted by Subbaiah and Kumaraswamy (1996). Application of green manuring and different organic sources of nutrients in maize-cowpea cropping sequence did not influence the harvest index of maize and it was found to be statistically non-significant.

Economics

Among the interaction of green manure and organic sources, higher cost of cultivation, gross returns, net returns and B:C ratio (Rs.72,150, Rs.2,23,386, Rs.1,51,236 ha^{-1} and 3.10) was recorded with the application of *in situ* incorporation of green manure *fb* combined application of different organic sources of nutrients *i.e.,* 25% N equivalent FYM + 25% N equivalent poultry manure + 25% N equivalent vermicompost + 25% N equivalent jeevamrutha (G_1M_9). However, lower gross returns, net returns and B:C ratio was recorded in absolute control (G_0M_1) plot *i.e.,* without green manure and no manure plot (Rs.1,17,848, Rs.55,123, Rs.12,192 ha^{-1} and 1.88) are presented in Table 7 and Fig. 4. The higher net return was due to increased gross returns coupled with comparatively lower cost of cultivation. The higher benefit cost ratio (B:C) ratio was attributed to higher gross returns with lower cost of cultivation. The results are in accordancee with the work of Parasuraman (2008) and Asghar *et al.* (2011).

Green manure (Sunhemp) *insitu* incorporation followed by integrated application of 25% N equivalent FYM + 25% N equivalent PM + 25% N equivalent vermicompost + 25% N equivalent jeevamrutha to maize significantly recorded higher grain yield (91.67 q ha^{-1}), stover yield (128.0 q ha^{-1}), net returns (Rs.1,51,236 ha^{-1}) and B: C ratio (3.10) as compared to other treatments.

Based on the results obtained, *insitu* incorporation of sunhemp as a green manure crop followed by combined application of 25 % N equivalent FYM + 25% N equivalent poultry manure + 25 % N equivalent vermicompost + 25% N equivalent jeevamrutha maize crop and growing cowpea as a residual crop was found to be economical and sustainable in maize-cowpea cropping sequence.

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