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Trend setting effect of different nutrient management approaches on soil properties and DTPA: Extractable micronutrients under maze based cropping system in Vertisol

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Abstract
An experiment with different nutrient management approaches was carried out during 3 consecutive years of 2019–20, 2020–21, and 2021–22 at Zonal Agricultural and Horticultural Research Station, Babbur farm, Hiriyur, situated in Central Dry Zone (Agro-Climatic Region IV) of Karnataka to evaluate the "Trend setting effect of different nutrient management approaches on soil physic-chemical properties under maze based cropping system in a Vertisol". The experiment consist of 4 treatments, *viz.*, T_1 – Natural farming - Seed treatment with Beejamrutha + Ghana jeevamrutha @ 1000 kg ha^{-1} before sowing + Jeevamrutha @ 200 L ha^{-1} @ 15 days interval + mulching at 30 DAS; T_2 – Organic farming - Seed treatment with *Rhizobium* + PSB + N equivalent basis of vermicompost; T_3 – Package of Practice – Recommended dose of N, P_2O_5, K_2O and FYM; T_4 – Farmers practice - FYM @ 7 t ha^{-1} and 45: 115 kg ha^{-1} N, P_2O_5, respectively in a randomized complete block design (RCBD) with 5 replications. The results revealed that application of organic manures such as vermicompost and FYM and concoctions like Jeevamrutha and Ghana jeevamrutha improved soil physical properties and soil organic carbon. Different nutrient management approaches did not have significant effect on soil pH, EC and free calcium carbonate content. The available N, P_2O_5, K_2O and S contents of soil increased slightly after harvest of the crop due to the incorporation of organic manures and bio fertilizers with chemical fertilizers, whereas DTPA-extractable micronutrients did not vary significantly among different nutrient management approaches. As a result, it is better to use the combination of organic and inorganic fertilizers in order to sustain soil fertility and environmental quality.

Keywords: Nutrient management approaches, soil, DTPA, maze based cropping system

Introduction

In the present agriculture production system, the biggest threat is the limitation of cultivable land and hence importance has been given increasing the production capacity of the available arable land. Hence, there is a need to increase the agricultural production from the same available arable land by intensive use of land resources, irrigation, fertilizers, pesticides, modern machineries and advanced techniques and therefore conventional farming practices has an important role in improving food productivity to meet over increasing human demands. Amongst the different elements, the key element that considered being the decisive factor is the soil. The inherent soil properties define the overall agriculture production and the capacity of the soil to maintain the fertility that, in turn, decides the production capacity or yield. These soil properties encompass the physical, chemical, and microbiological properties that render this soil system its dynamism. The physico-chemical properties of different soils have varying values owing to the abiotic and biotic variables that include but are not confined to-topography of the place, parent rock material, climate, and vegetation cover. In agricultural soils, the inputs that are added over a continued period of time are an important decisive factor in the soil fertility status. The chemical-based inputs have already raised several implications in terms of declining soil health (Prashar and Shah, 2016) [18]. Agri-management strategies that are based on traditional ecological knowledge (TEK) are gaining momentum owing to their better sustainability and adaptability (Sharma, 2017a) [21]. The traditional inputs that are best suited to the local needs and are easily available are promising alternatives for chemical amendments and maintaining soil fertility to achieve the goal of environmental sustainability (Sharma, 2017b) [22]. By considering the potentiality of organic and natural farming, in the present investigation, we have examined the impact of different nutrient management approaches such as natural farming (NF), organic farming (OF), package of practice (POP) and farmers practice (FP) on soil physical, chemical and physicochemical properties.

Material and Methods

The materials and methods used to study the comparative effects of natural, organic, integrated and farmers practices and physical and chemical properties of soil have been described and presented here as per details given below:

Location of the experimental site

The experiment was conducted at Zonal Agricultural and Horticultural Research Station, Babbur farm, Hiriyur, situated in Central Dry Zone (Agro-Climatic Region IV) of Karnataka. The geographical reference point of the experimental site was 13º 57' North latitude and 75º 38' East longitude, with an altitude of 606 meters above mean sea level (MSL).

Soil properties

An experiment with different nutrient supplying approaches such as natural, organic, integrated system was conducted since 2019-20 at a fixed location under maize based cropping system. The treatment wise composite soil samples were collected from each replication at 0 to 15 cm depth before the cropping season and collected samples were grounded with a wooden pestle and morter and passed through 2 mm sieve to separate coarse fragments (> 2 mm) and stored in plastic bags. The processed soil samples were used for further analysis by following standard procedures

The soil belongs to clay loam texture and black in color. The initial soil analysis data (Table 1) indicated that the soil was moderately alkaline in reaction with a normal electrical conductivity and low in organic carbon. Further, the soil was low in available nitrogen status, medium status for available phosphorus and available potassium. The experimental site was deficient in zinc and iron and sufficient in copper and manganese.

Weather conditions during the experiment

The monthly weather data such as rainfall, relative humidity, mean monthly maximum and minimum temperature during the experiment recorded from the agro meteorological observatory of Gramin Krushi Mausam Seva (GKMS) located at ZAHRS, Babbur farm, Hiriyur is presented in the Fig. 1. The mean monthly minimum temperature ranged from 14.2 to 21.6 °C and the mean monthly maximum temperature ranged from 27.7 to 36.1 °C during the crop growth period. The highest and lowest mean monthly minimum temperature was recorded during May and February, respectively, whereas the highest and lowest monthly maximum temperature was recorded during April and November, respectively. The mean monthly maximum relative humidity during the crop growth period ranged from 63 to 83 per cent, whereas the mean monthly minimum relative humidity during the crop growth period ranged from 27 to 47 per cent. The total rainfall received during crop growth period was 945.60 mm which was received from South-West and North- East monsoon. The highest rainfall was received during October (242.60 mm) followed by November (159.2 mm).

Cropping history of the experimental site

For the last two years (2019-20), experiments on different farming types are being conducted as permanent plots, consisting of natural, organic, conventional and Farmers practice plots. Under these plots, the maize crop was grown during summer and *Kharif* 2019 and 2020.

Experimental details

The experiment was laid out in a randomized block design with four different nutrient management approaches and five replications. The maize crop was grown during summer and *Kharif* 2021. The details of the treatments imposed in the experiment is given below;

Treatment details of summer maize

T_1	Natural farming	Seed treatment with Beejamrutha + Ghana jeevamrutha @ 1000 kg ha^{-1} before sowing + Jeevamrutha @ 200 L ha^{-1} @ 15 days interval + mulching at 30 DAS
T_2	Organic farming	Seed treatment with *Rhizobium* + PSB + N equivalent basis of vermicompost
T_3	Package of Practice	Seed treatment with *Rhizobium* + PSB + Recommended dose of FYM (10 t ha^{-1}) + 150:65:65 kg ha^{-1} N, P_2O_5, K_2O + $ZnSO_4$ @ 10 kg ha^{-1} + $FeSO_4$ @ 25 kg ha^{-1}
T_4	Farmers practice	FYM @ 7 t ha^{-1} and 45: 115 kg ha^{-1} N, P_2O_5

Treatment details of Kharif maize

T_1	Natural farming	Seed treatment with Beejamrutha + Ghana jeevamrutha @ 1000 kg ha^{-1} before sowing + Jeevamrutha @ 200 L ha^{-1} @ 15 days interval + mulching at 30 DAS
T_2	Organic farming	Seed treatment with *Rhizobium* + PSB + N equivalent basis of vermicompost
T_3	Package of Practice	Seed treatment with *Rhizobium* + PSB + Recommended dose of FYM (10 t ha^{-1}) + 100:50:25 kg ha^{-1} N, P_2O_5, K_2O + $ZnSO_4$ @ 10 kg ha^{-1}
T_4	Farmers practice	FYM @ 7 t ha^{-1} and 45: 115 kg ha^{-1} N, P_2O_5

The result of analysis of FYM, vermicompost, jeevamrutha and Ghana jeevamrutha is given in Table 2.

Soil sampling and analysis

The composite soil samples were collected from all the treatments and replications from 0-15 cm depth and samples were processed and analyzed for different parameters such as bulk density was determined by Core sampler method and expressed in Mg m^{-3} as given by Piper (1966) [17]. Particle density was determined by using Pycnometer and expressed in Mg m^{-3} as given by Piper (1966) [17]. Maximum water holding capacity of soil was determined by using Keen-Raczkowaski brass cup as described by Piper (1966) [17]. Porosity of soil was computed by substituting the values of particle density (PD) and bulk density (BD) densities in the equation (Black, 1965) [3]. Soil pH was determined in 1:2.5

soil: water suspension by potentiometric method using glass electrode in association with reference electrode (Jackson, 1973) [7]. The electrical conductivity (EC) of soil was determined in 1:2.5 soil: water suspension using Conductivity Bridge and the results were expressed in dS m^{-1} at 25 °C (Jackson, 1973) [7]. The organic carbon content of finely ground soil samples was determined by Walkley and Black's wet oxidation method as described by Jackson (1973) [7] and expressed in g kg^{-1} soil. The free calcium carbonate content of soil samples was determined by rapid acid titration method as described by Piper (1966) and expressed in per cent. The cationic micronutrients *viz*., copper, iron manganese and zinc were extracted by 0.005 *M* DTPA (Diethylene Triamine Penta Acetic acid) extract ant and 0.01M $CaCl_2$ + 0.1 N Triethanalamine at pH 7.3, in the ratio of 1:2 soil to extract ant and shaking for two hours, as explained by Lindsay and Norvell (1978) [11]. The concentration of micronutrients (mg kg^{-1}) was estimated using Atomic Absorption Spectrophotometer.

Results and discussion

The data in Table 3 indicated that bulk density did not vary significantly amongst the different nutrient management approaches under both the crops. However, numerically higher value of bulk density was recorded under farmers practice (1.14 and 1.14 Mg m^{-3}) followed by package of practice (1.13 and 1.13 Mg m^{-3}) and natural farming (1.12 and 1.11 Mg m^{-3}) under summer and *Kharif* maize, respectively. The organic farming approach recorded the lowest soil bulk density (1.11 and 1.10 Mg m^{-3} under summer and *Kharif* maize, respectively). The reduced bulk density in organic framing treatment might be due to increased soil bio pores and soil aeration, higher soil organic carbon content and better soil aggregation by the application of bulky organic manures that ultimately improved soil porosity and water holding capacity as well. Similarly, Singh *et al.* (2022) [23] reported that the application of FYM @ 20 t ha^{-1} recorded lowest bulk density followed by FYM 10 t ha^{-1} + 100% NPK treatment under wheat-maize cropping system in Udaipur, Rajasthan.

Research indicated that soil aggregates formed as a result of adding soil organic manures possessing more pore space than any other soil aggregation. Such pore space distribution reduce weight per unit volume of soil and thus reduces bulk density and increase soil porosity. The result obtained corroborates the findings of Mahmood *et al.* (2017) [12], Abid *et al.* (2020) [1], Jalal *et al.* (2020) [8], Trivedi *et al.* (2020) [26] under maize crop.

A perusal of data in Table 3 revealed no significant effect of different nutrient management approaches on soil particle density under both the crops. Numerically higher values of particle density were recorded under farmers practice (1.95 Mg m^{-3}) followed by package of practice (1.94 Mg m^{-3}) and natural farming (1.93 Mg m^{-3}) under summer maize. A similar trend was followed under *Kharif* maize where farmers practice recorded numerically higher particle density (1.94 Mg m^{-3}) followed by package of practice (1.93 Mg m^{-3}). Organic farming treatment recorded numerically lower particle density (1.93 and 1.92 Mg m^{-3}) under summer and *Kharif* maize, respectively. Similar results were reported by Dhaliwal *et al.* (2021) [4] where lower particle density of surface soil was recorded in the treatments incorporated with organic manure alone.

The data depicted in Table 3 indicated that the nutrient management approaches did not have any significant effect on maximum water holding capacity of soil under both the crops. The numerically higher maximum water holding capacity was observed in organic farming (63.54 and 63.92%) followed by natural farming (63.01 and 63.22%) and package of practice (62.82 and 62.99%) treatments, under summer and *Kharif* maize, respectively. The lower maximum water holding capacity was observed in farmers practice treatment (61.22 and 61.34%) under summer and *Kharif* maize, respectively.

Our results are in line with many previous studies which reported that the addition of cattle manure, FYM, vermicompost, crop residues and green manures in soils increased the soil structure, soil aggregation, number of micro and macro pores and thus increase the water-holding capacity (Subhan *et al.*, 2017 and Abid *et al.*, 2020) [25, 1]. Higher maximum water holding capacity in the present study was observed under vermicompost treatments as compared to FYM treatments which showed that type of organic matter also affects the maximum water holding capacity. The high organic matter content of vermicompost as compared to FYM increased the number of micro-pores in vermicompost treatments which were responsible for higher maximum water holding capacity as compared to FYM treatments. Also, the inclusion of bio fertilizers led to the rapid mineralization of added organic matter and subsequent release of carbon in bio fertilizers added treatments.

The data presented in Table 3 indicated that the nutrient management approaches did not have significant effect on porosity of soil under both the crops. Under summer maize crop, numerically higher porosity was observed in T_2 treatment (42.49%) consisting of 100 per cent N supplementation through organics, which was followed by T_1 treatment (41.97%) comprising of mulching, jeevamrutha and Ghana jeevamrutha application. The lower porosity was observed in T_4 treatment (41.54%) received FYM @ 7 t ha^{-1} + 45: 115 kg of N and P_2O_5 ha^{-1}. Under *Kharif* maize crop, numerically higher porosity was observed in organic farming treatment (42.71%) followed by natural farming (42.49%) and package of practice (41.58%), while farmers practice treatment had lower porosity (41.20%). With the application of organic manure, the tightness in the soil profile is significantly reduced. These results are also in accordance with previous findings suggesting (Haridha *et al.*, 2020, Noor *et al.*, 2020 and Singh *et al.*, 2022) [6, 15, 23] that soil aggregation and porosity are essentially improved by the presence of soil organic matter and microbiological activity.

The data related to soil pH in Table 4 indicated that, nutrient management approaches did not have significant effect on soil reaction under both the crops. However, organic farming had lower pH (8.71 and 8.72) followed by natural farming (8.74 and 8.76) under summer and *Kharif* maize, respectively. Similar non-significant results were found by Vinay *et al.* (2020a) [27] under maize crop. The buffering capacity of the soil could be the main reason for the pH stability.

The data in the Table 4 revealed that, electrical conductivity ranged from 0.35 to 0.39 dS m^{-1} and 0.35 to 0.38 dS m^{-1} after harvest of summer and *Kharif* maize, respectively and it did not vary significantly among different nutrient management approaches. The organic manures played the role of buffer in soil and mineralization and decomposition of organics release free cations, resulting in the stability of the electrical conductivity. Similarly, Meena *et al.* (2020) [13] found no appreciable change in the EC under both rice-wheat-mung bean and rice-wheat cropping systems in a *Typic Ustochrept* soil of India.

In Vertisol, free calcium carbonate ranged from 1.28 to 1.64 per cent and 1.26 to 1.64 per cent under summer and *Kharif* maize, respectively, and it did not vary significantly among the different nutrient management approaches (Table 4). Numerically higher free calcium carbonate was observed in the treatments with integrated use of organics and in-organics treatment (package of practice and farmers practice). The lowest amount of free calcium carbonate was registered with the application of 100 per cent organics (organic and natural farming). The reduction in free $CaCO_3$ might be due to the release of organic acids during the decomposition of organic materials which react with $CaCO_3$ to release CO_2 thereby reducing $CaCO_3$ content of the soil. Similar results were found by Panghate *et al.* (2020) [16].

It is apparent from the data presented in Table 5 that different nutrient management approaches had a significant effect on soil organic carbon at various growth stages of both the crops. At 30 DAS of summer maize, among nutrient management approaches, organic farming treatment received 100% N through vermicompost recorded significantly higher organic carbon content (6.83 g kg^{-1}) and was statistically on par with package of practice with recommended dose of FYM and N, P_2O_5 and K_2O (6.46 g kg^{-1}) and significantly superior over farmers practice received FYM @ 7 t ha^{-1} + 45: 115 kg of N and P_2O_5 ha^{-1} (6.26 g kg^{-1}). Significantly lower organic carbon content was observed under natural farming treatment comprising of jeevamrutha and Ghana jeevamrutha (6.01 g kg^{-1}). At 60 DAS and at harvest of summer maize, there was significant variation in the soil organic carbon content with respect to nutrient management approaches. Among the treatments, significantly highest organic carbon was recorded in organic farming (6.51 and 6.29 g kg^{-1}) followed by package of practice (6.17and 5.94 g kg^{-1}) and farmers practice treatment (6.01 and 5.81 g kg^{-1}) while significantly lowest soil organic carbon was recorded under natural farming treatment (5.71 and 5.47 g kg^{-1}) at 60 DAS and at harvest of maize, respectively.

Similarly, different nutrient management approaches had significant effect on organic carbon content at 30 DAS, 60 DAS and at harvest of *Kharif* maize. At 30 DAS, significantly higher organic carbon was observed under organic farming (7.50 g kg^{-1}) followed by package of practice (6.92 g kg^{-1}) and farmers practice (6.59 g kg^{-1}), while lowest soil organic carbon was recorded under natural farming treatment (6.11 g kg^{-1}). At 60 DAS and at harvest of *Kharif* maize, there was significant variation in the soil organic carbon content with respect to nutrient management approaches. Among the treatments, significantly highest organic carbon was recorded under organic farming (6.98 and 6.64 g kg^{-1}), which was statistically at par with package of practice (6.51 and 6.27 g kg^{-1}) and farmers practice treatments (6.27 and 6.08 g kg^{-1}) while, significantly lowest soil organic carbon was recorded under natural farming treatment (5.83 and 5.65 g kg^{-1}) at 60 DAS and at harvest, respectively.

The continuous addition of organic manures resulted in higher soil organic carbon, indicating soil as a best carbon sink even in semi-arid conditions (Dutta *et al.*, 2018) [5]. The effect was further enhanced resulting in higher root and shoot growth and thus increased production of biomass might have raised the organic carbon content in soil (Baishya *et al.*, 2017) [2]. The results were supported by the findings of Karikatti *et al.* (2020) [9] in a clayey textured Vertisol. Maximum soil organic carbon was observed @ 30 DAS and then declined at harvesting stage under both summer and *Kharif* maize crops. Similarly, Purohit *et al.* (2019) [19] reported that maximum SOC was observed at tillering stage of rice followed by panicle initiation and maturity stages. The increase in SOC content at 30 DAS could be due to higher production of root exudates.

It appears from the data presented in Table 6 that, there was no significant variation observed in Zn, Fe, Mn and Cu status of post-harvest soil influenced by the nutrient management approaches. Under summer maize, numerically maximum amount of Fe and Zn was recorded in package of practice (5.03 and 1.26 mg kg^{-1}, respectively), which was followed by rest of the treatments. Numerically higher amount of Mn was recorded in organic farming (4.17 mg kg^{-1}), while Cu in farmers practice treatment (1.13 mg kg^{-1}). Lower values for status were recorded with natural farming treatment (4.31, 3.89, 1.02 and 0.98 mg kg^{-1}, respectively) and a similar trend was followed for all the micronutrients except for Zn under *Kharif* maize. Significantly higher zinc status was observed under package of practice (0.68 mg kg^{-1}) followed by organic farming (0.57 mg kg^{-1}) and farmers practice (0.42 mg kg^{-1}) treatments. While, significantly lower Zn was observed in natural farming treatment (0.37 mg kg^{-1}).

Khan *et al.* (2017) [10] also confirmed that organic manures as a source of micro-nutrients in agricultural soils that are slowly and gradually added to the soil nutrient pool upon FYM mineralization. Increase in micronutrients in the package of practice, organic farming and farmers practice treatments, irrespective of its significance level may be ascribed to higher below ground biological mass due to comparatively higher crop growth and the resulted higher organic matter content. In addition, chelating action of FYM during decomposition of organic manures increases the availability of micronutrient cations and also protected these cations from fixation. A similar result was obtained by Moharana *et al.* (2017) [14] under a six-year old pearl millet-wheat cropping system at the research farm of IARI, New Delhi.

Table 1: Initial properties of the soil in the experimental site

Parameters	Value
Physical properties	
Texture	Clay loam
Bulk density (Mg m^{-3})	1.16
Particle density (Mg m^{-3})	1.96
Maximum water holding capacity (%)	59.28
Porosity (%)	30.20
Chemical properties	
pH (1:2.5)	8.80
Electrical conductivity (1:2.5) (dS m^{-1}) @ 25 °C	0.48
Organic carbon (g kg^{-1})	4.12
Available N (kg ha^{-1})	265.41
Available P_2O_5 (kg ha^{-1})	40.52
Available K_2O (kg ha^{-1})	392.25
Exchangeable Ca [Cmol(p+) kg^{-1}]	30.89
Exchangeable Mg [Cmol(p+) kg^{-1}]	12.92
Available S (mg kg^{-1})	22.15
DTPA-Fe (mg kg^{-1})	4.16
DTPA-Mn (mg kg^{-1})	4.04
DTPA-Zn (mg kg^{-1})	0.33
DTPA-Cu (mg kg^{-1})	1.23

Table 2: Chemical composition of manures used in the experiment

	Ghana jeevamrutha	Jeevamrutha	Vermicompost	FYM
Total nitrogen (%)	1.98	1.13	1.32	0.76
Total phosphorus (%)	0.62	0.26	0.47	0.41
Total potassium (%)	0.75	0.34	0.78	0.37
Total sulphur (%)	0.53	0.29	0.42	0.39
Total calcium (%)	0.82	0.78	1.12	1.04
Total magnesium (%)	0.62	0.52	0.82	0.76
Total zinc (ppm)	86.32	28.52	102.15	65.23
Total manganese (ppm)	112.23	21.05	121.25	98.23
Total copper (ppm)	48.22	6.25	45.17	42.15
Total iron (ppm)	821.14	232.12	2051	582.16

Table 3: Influence of nutrient management approaches on soil physical properties at harvest under maize-maize cropping sequence in Vertisol

Treatments	Bulk density (Mg m^{-3})		Particle density (Mg m^{-3})		Maximum water holding capacity (%)		Porosity (%)	
	Summer maize	*Kharif* maize	Summer maize	*Kharif* maize	Summer maize	*Kharif* maize	Summer maize	*Kharif* maize
Natural farming	1.12	1.11	1.93	1.93	63.01	63.22	41.97	42.49
Organic farming	1.11	1.10	1.93	1.92	63.54	63.92	42.49	42.71
Package of practice	1.13	1.13	1.94	1.93	62.82	62.99	41.71	41.58
Farmers practice	1.14	1.14	1.95	1.94	61.22	61.34	41.54	41.20
S Em±	0.039	0.043	0.070	0.077	2.26	2.49	0.58	0.81
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS

Table 4: Influence of nutrient management approaches on pH, EC and free $CaCO_3$ at harvest under maize-maize cropping sequence in Vertisol

Treatments	pH		EC (dS m^{-1})		Free $CaCO_3$ (%)	
	Summer maize	*Kharif* maize	Summer maize	*Kharif* maize	Summer maize	*Kharif* maize
Natural farming	8.71	8.72	0.37	0.35	1.32	1.31
Organic farming	8.74	8.76	0.35	0.36	1.28	1.26
Package of practice	8.79	8.83	0.36	0.37	1.61	1.60
Farmers practice	8.83	8.81	0.39	0.38	1.64	1.64
S Em±	0.31	0.45	0.01	0.01	0.10	0.11
CD @ 5%	NS	NS	NS	NS	NS	NS

NS: Non significant

Table 5: Influence of nutrient management approaches on soil organic carbon (g kg^{-1}) at different growth stages of summer and *Kharif* maize under maize-maize cropping sequence in Vertisol

Treatments	Summer maize			*Kharif* maize		
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
Natural farming	6.01	5.71	5.47	6.11	5.83	5.65
Organic farming	6.83	6.51	6.29	7.50	6.98	6.64
Package of practice	6.46	6.17	5.94	6.92	6.51	6.27
Farmers practice	6.26	6.01	5.81	6.59	6.27	6.08
S Em±	0.18	0.17	0.18	0.24	0.25	0.22
CD @ 5%	0.56	0.52	0.54	0.75	0.77	0.67

Table 6: Influence of nutrient management approaches on soil available micronutrient status (mg kg^{-1}) at harvest under maize-maize cropping sequence in Vertisol

Treatments	Summer maize				*Kharif* maize			
	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu
Natural farming	4.31	3.89	1.02	0.98	4.14	3.42	0.37	0.90
Organic farming	4.68	4.17	1.17	1.08	4.92	4.02	0.57	1.19
Package of practice	5.03	4.12	1.26	1.11	4.97	3.98	0.68	1.11
Farmers practice	4.72	4.08	1.12	1.13	4.82	3.87	0.42	1.09
S Em±	0.274	0.150	0.060	0.037	0.29	0.15	0.02	0.07
CD @ 5%	NS	NS	NS	NS	NS	NS	0.05	NS

DAS: Days after sowing
NS: Non significant

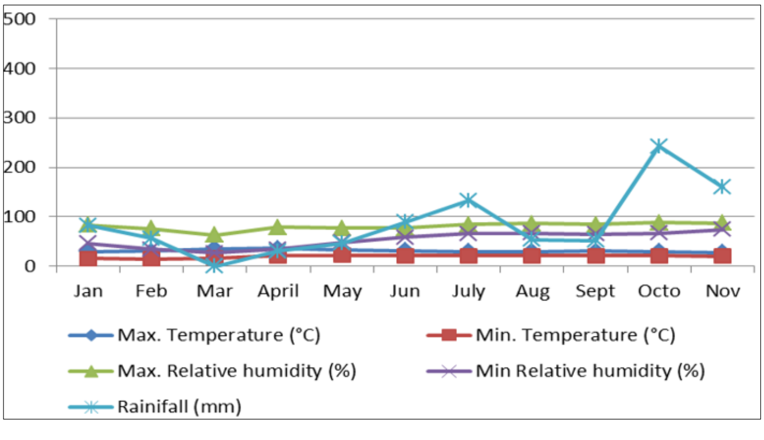

Fig 1: Mean monthly meteorological data during the cropping period of 2021 at the meteorological observatory, ZAHRS, Babbur farm, Hiriyur

Conclusions

The results based on our study have indicated that the physical soil attributes, such as bulk density, particle density, porosity and maximum water holding capacity have improved with the application of organic manures such as vermicompost and FYM and concoctions like Jivamrutha and Ghana jeevamrutha. The application of organic manures along with chemical fertilizers provided higher available nutrients compared to chemical fertilizer or organic manures alone. In the present scenario-where chemical fertilizers had already shown detrimental effects in the form of long-term soil fertility depletion, health concerns occurring due to chemical inputs to both the growers and consumers, environmental deterioration-ecologically sustainable agri-management systems such as organic and natural farming are not a choice but a necessity. This is a first of its kind study to assess the certain important physico-chemical properties in traditional versus chemical-based agri-management systems in semi-arid tropics. The arid and semi-arid tropics are highly prone to stressors like drought, highly erratic rainfall patterns, and salinity, and the present study advocates the supremacy of addition of organic manures in soil sustainability for maintaining soil fertility in the long run.

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