



Influence of Magnesium in Combination with Organics on the Yield and Uptake of Nutrients by Cotton (*Gossypium hirsutum* L.) Crop in *Typic ustropept*

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Authors' contributions

This work was carried out in collaboration among all authors. Authors KR and PSP designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author RS managed the analysis of study. Authors KK and AG managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted to evaluate the effects of magnesium and organic manures on yield and nutrient uptake of cotton (*Gossypium hirsutum* L.) between 28th Aug 2019 and Jan 2020 in a farmer's field located at Achchandavilthan village of Srivillipudhur block, Virudhunager district, Tamil nadu. This experiment comprised of fifteen treatment with three replication involving magnesium in combination with organics. The results revealed that the application of MgSO₄ at the rate of 50 kg ha⁻¹ along with 250 kg vermicompost for 30 days (1:5 ratio) at critical stages of crop growth along with the Soil Test Crop Response (STCR) based N,P₂O₅ and K₂O registered maximum nutrient uptake of major nutrients Nitrogen (14.25, 23.60 and 43.50 kg ha⁻¹), Phosphorus (6.25, 7.80 and 10.34 kg ha⁻¹), Potassium (20.35, 34.50 and 47.45 kg ha⁻¹) 40,70 DAS and harvest

stage, secondary nutrient like Calcium(20.54, 33.21 and 69.21 kg ha⁻¹), Magnesium (4.65, 5.75 and 10.50 kg ha⁻¹) 40, 70 Day after sowing (DAS) and harvest stage and micro nutrient Iron (1185.6, 1975.6 and 4865.2 325.80g ha⁻¹), Manganese (380.5, 530.2 and 792.3 325.80), Zinc (90.65, 155.72 and 325.60 325.80), and Copper (90.62, 155.70 and 325.80 325.80) 40, 70 DAS and harvest stage of crop growth.

Keywords: Cotton; farmyard manure; vermicompost; nutrient uptake; yield.

1. INTRODUCTION

Magnesium (Mg) is the eighth most abundant element in the earth's crust, as well as the second most common cation in plants. It is a common element in many minerals; however, because to the slow weathering and releasing process, roughly 90–98% of Mg is integrated in the crystal lattice structure of minerals and hence not immediately available for plant absorption [1]. Plants absorb a smaller amount of Mg from the soil solution generated by soil minerals, therefore extra dose must be obtained from outside sources, such as fertilizers to meet the crop's nutritional requirements. Because Mg is a mobile nutrient in soil, Mg fertilizers, especially the soluble form of sulphate fertilizers, are easily leached off. Mg insufficiency is prevalent in crops, not only owing to leaching losses of Mg nutrient from the soil, but also due to antagonistic interactions of Mg with H⁺, Al³⁺, NH⁴⁺, and Mn²⁺ in acid soil (pH 7.0), Ca²⁺ and Na⁺ in alkaline soil (pH > 7.0), and K⁺ in high potassium (K) containing soil [2] Despite the fact that 'Mg,' a secondary plant nutrient, is the only mineral in the central atom of chlorophyll and a mobile nutrient in plants older leaves of Mg deficient plants show interveinalchlorosis, or chlorophyll breakdown between the veins.

Cotton, sometimes known as the "King of Fibre," is a key cash crop in India and one of the crops with a high Mg demand. It is also extremely sensitive to the Mg nutrient, which aids in their growth and development. Apart from the most important functions of Mg, which include photo phosphorylation (such as ATP formation in chloroplasts), enzyme activation [Ribulose-1,5-bisphosphate (RuBP) carboxylase involved in photosynthesis], photosynthetic carbon dioxide (CO₂) fixation, protein synthesis, chlorophyll formation, phloem loading, partitioning, and utilisation of photo assimilates, generation of reactive oxygen species, and photo oxidation in leaf [3]. Cotton is often cultivated on heavy clay soils with a high pH (>7.0), where Mg uptake is restricted due to increased calcium buildup and their antagonistic interaction effect (Fageria,

2001). Foliar feeding is an efficient approach to raise Mg content in different regions of the plant and boost yield when compared to soil application of Mg nutrients, and comparable results have been found in cotton by Mobarak et al., [4] and Singh, Rathore, and Gumber [5].

As the cotton is grown predominantly in Vertisol under calcareous condition, leads to the fixation of MgCO₃ and Mg(OH)₂, the imbalance between the calcium and magnesium might be one of the major causes for magnesium deficiency. The low yield in cotton due to imbalance nutrition and lack of high quality seed. Mg deficiency is a serious problem in cotton that affect the productivity, In the base saturated black-clay soils, a proper balance between Ca:Mg is necessary for optimum calcium, magnesium nutrition. Therefore, instead of applying magnesium sulphate as such as basal, it can be applied in combination with organic manures. The enhancement effect of magnesium EDTA than magnesium sulphate on leaf total chlorophyll content may be due to that magnesium chelate remains in a soluble form and easy for plant uptake [6].

However, there is a scarcity of studies on the usefulness of Mg in combination with organic manures on Mg-responsive crops such as cotton. Therefore, the present study was carried out to evaluate the effect of magnesium in conjoint with organic manures on the yield and uptake of nutrient by the cotton crop.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The experiment was conducted during Autumn season (Aug-2019 to Jan 2020) in a farmer field at Achchandavilthan village, Srivillipudhur block, Virudhunagar district, Tamil nadu. The farm is located at 9.51'92" North Latitude and 77.66'74" East Longitude. The soils of the experimental site was clay loam with soil pH (8.4), Electrical conductivity (EC) (0.32 dS m⁻¹) and Organic carbon (OC) (3.94 g kg⁻¹). The soil was low in

available nitrogen (218.0 kg ha⁻¹), medium in available phosphorus (14.3 kg ha⁻¹) and medium in available potassium (356.0 kg/ha). The yield and nutrient uptake data were recorded at 40, 70 DAS and after the harvest of the crop. The yield and uptake (kg ha⁻¹) obtained in the study were subjected to statistical scrutiny by analysis of variance (ANOVA) as outlined by Panse and Sukhatme (1967).

2.2 Enrichment of Organics Fortified with Mg

The organic sources employed in the incubation of Mg are vermicompost and farmyard manure. The enrichment process include MgSO₄ @ 50 kg ha⁻¹ incubated with 250 kg vermicompost for 30 days (1:5 ratio), MgSO₄ @ 50 kg ha⁻¹ incubated with 500 kg Farm yard manures for 30 days (1:10 ratio), MgSO₄ @ 37.5 kg ha⁻¹ incubated with 375 kg FYM for 30 days (1:10 ratio), MgSO₄ @ 25 kg ha⁻¹ incubated with 250 kg FYM for 30 days (1:10 ratio), MgSO₄ @ 37.5 kg ha⁻¹ incubated with 187.5 kg vermicompost for 30 days (1:5 ratio), MgSO₄ @ 25 kg ha⁻¹ incubated with 125 kg vermicompost for 30 days (1:5 ratio).

2.3 Experimental Design and Treatments

The field experiment was conducted in randomized block design with fifteen treatments and three replications, with a plot size 5 m x 4 m. The details of treatments are T₁ - Recommended N, P₂O₅ and K₂O @ 80:40:40 kg ha⁻¹, T₂ - N, P₂O₅ and K₂O on STCR basis, T₃ - T₂ + Basal application of MgSO₄ @ 37.5 kg ha⁻¹, T₄ - T₂ + MgSO₄ @ 37.5 kg ha⁻¹ incubated with 375 kg FYM, T₅ - T₂ + MgSO₄ @ 25 kg ha⁻¹ incubated with 250 kg FYM, T₆ - T₂ + MgSO₄ @ 37.5 kg ha⁻¹ incubated with 187.5 kg vermicompost, T₇ - T₂ + MgSO₄ @ 25 kg ha⁻¹ incubated with 125 kg vermicompost, T₈ - T₂ + Basal application of MgSO₄ @ 50 kg ha⁻¹, T₉ - T₂ + MgSO₄ @ 50 kg ha⁻¹ incubated with 500 kg FYM, T₁₀ - T₂ + MgSO₄ @ 50 kg ha⁻¹ incubated with 250 kg Vermicompost, T₁₁ - T₂ + Foliar application of MgSO₄ @ 1% on 20, 40, 60 DAS, T₁₂ - T₃ + Foliar application of MgSO₄ @ 1% on 20, 40, 60 DAS, T₁₃ - T₈ + Foliar application of MgSO₄ @ 1% on 20, 40, 60 DAS, T₁₄ - T₂ + Basal application of EDTA @ 2 kg ha⁻¹, T₁₅ - T₂ + Foliar application of Mg EDTA @ 0.5% on 20 40 60 (DAS) Day after sowing. The data were analyzed with the help of a window-based computer package OPSTAT (ANOVA) to calculate standard error of means SE(m), standard

error of difference in mean SE(d), and critical difference between treatments mean CD.

3. RESULTS AND DISCUSSION

3.1 Effect of Magnesium and Fortified Organic Nutrients on Seed Yield Cotton

Incubated of magnesium with vermicompost showed a significant impact on the number of bolls plant⁻¹, boll weight (g), seed cotton yield. among the various treatment combination application of MgSO₄ @ 50 kg ha⁻¹ incubated with 250 kg vermicompost for 30 days (1:5 ratio) along with STCR based N, P₂O₅ and K₂O at was found to be effective in increasing seed cotton yield (26.2 q ha⁻¹), followed by MgSO₄ @ 50 kg ha⁻¹ incubated with 500 kg FYM for 30 days (1:10 ratio) along with STCR based N, P₂O₅ and K₂O. The treatment T₁₄, T₄, T₅, T₆ statically on par with each other. The lowest seed cotton yield (17.5 q ha⁻¹) was recorded in the recommended dose of fertilizer treatment receiving (T₁).

The catalytic involvement of magnesium in various enzymatic pathways might explain the much greater seed cotton production in combination treatments of MgSO₄ with organic manures. In the presence of organics, magnesium's positive impact was shown to be greater. Organics, on the other hand, improved the physical, chemical, and biological qualities of the soil as well as the delivery of nutrients throughout the crop's growth, resulting in better seed cotton yield in all organic treatments than in the other treatments. The usage of organic manures such as FYM boosts microbial activity, which aids in the transformation of nutrients and makes them more accessible to plants. Similar results were reported by Tayade *et al.*, (2011).

The influence of various nutrient management systems on seed cotton output is significant. When 100 percent RDF was combined with vermicompost, the seed cotton produced the maximum. This might be related to the cotton crop's mineralization and slow nutrient release, which results in improved nutrient absorption and increased seed cotton output when grown on vermicompost observed by Mohadeseh *et al.*, [7].

The results of Zhang and Flottman [8] demonstrated that if the number of pods is reduced owing to a lack of photoassimilates during flowering time, other yield components

will not be able to compensate for the yield loss caused by the reduced pod number. The increased plant density caused by appropriate Mg treatments is most likely attributable to greater seedling vigour and growth as a result of higher glucose accumulation in Mg adequate plants. Seeds collected from Mg sufficient plants have also been proven to have significantly improved germination and seedling growth in numerous investigations [9]. Ensuring high Mg seedlings and/or seeds can contribute greatly to plant density and thus better seed yield in the region.

3.2 Effect of Magnesium and Fortified Organic Nutrients on Nutrient Uptake

3.2.1 Nitrogen uptake

The results revealed that a significant influence of Mg with organic manures on N uptake. The N uptake was significantly higher while incorporating $MgSO_4$ in combination with organic manures along with N, P_2O_5 and K_2O on STCR basis in all the three growth stages of cotton crop. The N uptake ranged from 5.95 to 14.25 $kg\ ha^{-1}$ at flowering stage, 9.35 to 23.60 $kg\ ha^{-1}$ boll development and 20.24 to 43.50 $kg\ ha^{-1}$ at harvest stages. The highest N uptake was recorded in the treatment T_{10} ($MgSO_4$ @ 50 $kg\ ha^{-1}$ incubated with 250 kg vermicompost along with N, P_2O_5 and K_2O on STCR basis) with the values 14.25, 23.60, 43.50, at 40, 70 DAS and at harvest stages respectively. Followed by the treatment T_9 . The treatment T_{14} which was statistically at par with T_4 , T_5 , T_6 . The lowest uptake at 40 DAS (5.95 $kg\ ha^{-1}$), 70 DAS (9.35 $kg\ ha^{-1}$) and at harvest stage (20.24 $kg\ ha^{-1}$) were recorded in the treatment applied with recommended N, P_2O_5 and K_2O (T_1).

The lack of a distinct response of grain N concentration to Mg feed in this investigation might be ascribed to dilution as a result of Mg large yield boost. The grain N yield, on the other hand, clearly demonstrates that increased Mg supply increased N usage [10]. In Mg-deficient situations, both the uptake and absorption of N are hampered [11].

Mg application was increased, which boosted N concentrations, particularly in the pod wall, and resulted in considerable increases in total N intake. Root N absorption and assimilation of root-absorbed N are energy-intensive processes that need the usage of a lot of Mg-ATP reported by [12]. Mg nutritional status of plants may alter

nitrogen absorption by influencing glutamine synthetase activity [13]. Mg enhances root absorption and shoot accumulation of N in soybean plants by altering the expression of the genes producing nitrate transporters ($NRT2.1$ and $NRT2.2$), according to a recent article [14].

3.2.2 P uptake

The P uptake ranged from 1.19 to 6.25 $kg\ ha^{-1}$ at 40 DAS, 2.90 to 7.80 $kg\ ha^{-1}$ 70 DAS and 5.45 to 10.34 $kg\ ha^{-1}$ at harvest stages of cotton crop. The highest P uptake of 6.25, 7.80 and 10.34 $kg\ ha^{-1}$ at 40, 70 DAS and harvest stage respectively were registered in the treatment receiving $MgSO_4$ @ 50 $kg\ ha^{-1}$ incubated with 250 kg vermicompost for 30 days (1:5 ratio) along with N, P_2O_5 and K_2O on STCR basis (T_{10}), followed by the treatment receiving $MgSO_4$ @ 50 $kg\ ha^{-1}$ incubated with 500 kg FYM for 30 days (1:10 ratio) along with N, P_2O_5 and K_2O on STCR basis (T_9). The lowest P uptake of 1.19, 2.90 and 5.45 $kg\ ha^{-1}$ at 40, 70 DAS and at harvest stage respectively were registered in the treatment T_1 (RDF alone).

Mg can form stable bonds with over 90% of phosphate nucleotides in plants and serves as a cofactor in several enzymatic reactions related to phosphorylation, dephosphorylation, and hydrolysis of different substances in plants, as well as a bridging element for the aggregation of ribosome subunits required for protein synthesis [15]. Mg deficiency will paralyse various enzymatic activities that need the transfer of phosphate groups, which will have a direct impact on cellular metabolism [16]. The application of Mg sources of fertilizer enhanced the plant's phosphorus content as well. The use of magnesium fertilizers improved the plant's P content in a synergistic manner [17].

P content of the plant was significantly raised by enriched MgO fertilizers as compared to normalized $MgSO_4$ fertilizers. MgO nanoparticles are adsorbed on plant surfaces and taken in through natural plant apertures on the nano or micrometre size. Nanoparticles may reach the xylem through the cortex and central cylinder, accumulating in the vacuole. There are a lot of researchers [18,19].

3.2.3 K uptake

As observed in N and P uptakes, the uptake of potassium by cotton crop was also significantly influenced due to the applied treatments. Similar to N and P uptake, the treatment which had

received MgSO_4 incubated with vermicompost along with N, P_2O_5 and K_2O on STCR basis registered significantly higher K uptake than other treatments. With regard to the K uptake of cotton grown in the soil, it varied from 12.15 to 20.35, 18.35 to 34.50 and 28.15 to 47.45 kg ha^{-1} at 40, 70 DAS and at harvest stages respectively. Among the various treatments imposed, the highest K uptake were recorded in the treatment T_{10} (MgSO_4 incubated with vermicompost along with N, P_2O_5 and K_2O on STCR basis) at all the three stages of crop growth. At all the three stages, the lowest K uptake (12.15, 18.35 and 28.15 kg ha^{-1}) was noticed in T_1 which was fertilized with recommended dose of fertilizer alone.

The experimental soil had an alkaline response (pH 8.5) and a high K content (912 kg ha^{-1}), however the normally noticeable antagonistic interaction between Mg and K was not observed in cotton plants, perhaps owing to Mg fertilization through leaves. This result was supported by Jezek et al., (2014). Who discovered that resupplying MgSO_4 through the leaves boosted the K content in maize plants more than resupplying Mg through the roots. It was determined that applying Mg via roots causes rivalry for K absorption from the soil, but applying Mg via foliar provides no competition for Mg uptake of K due to the absence of Mg as a competitor at the root side and lower Mg concentration in root tissues. Similar findings were provided by Mobarak et al., [4] Potassium suppresses Mg absorption through non-specific Mg transporters on root cell membranes, resulting in large reductions in Mg concentrations in plants reported by Senbayram et al., [20].

The antagonistic effect between K and Mg was well elucidated in reviews by Senbayram et al., [20] and Yan and Hou [21]. They discovered that when the K content at the soil-root interface is high, Mg uptake by roots is unaffected, but non-specific Mg transporters severely limit Mg translocation from root to shoot.

3.2.4 Calcium uptake

The effect of magnesium along with organic manures on Ca uptake by cotton at all the three stages of crop growth is presented in table. Among the treatments, T_{10} which received with $\text{MgSO}_4 @ 50 \text{ kg ha}^{-1}$ incubated with 250 kg vermicompost for 30 days (1:5 ratio) along with N, P_2O_5 and K_2O on STCR basis recorded the maximum Ca uptake of 20.54, 33.21 and 69.21

Kg ha^{-1} , followed by it, the treatment receiving $\text{MgSO}_4 @ 50 \text{ kg ha}^{-1}$ incubated with 500 kg FYM for 30 days (1:10 ratio) along with N, P_2O_5 and K_2O on STCR basis (T_9) was found to be the best performing, However, the lowest Ca uptake of 12.35, 14.22, and 43.25 kg ha^{-1} at all the three stages of crop growth were recorded in the crop T_1 (RDF alone).

Significant influence of treatments on Ca uptake by cotton crop was recorded at 30 DAS, 60 DAS and at harvest stages. This may due to the narrow C:N ratio of vermicompost which would have released the nutrients to the labile pool easily. These results are in conformity with the findings of Ghosh et al. [22].

3.2.5 Magnesium uptake

The data pertaining to the Mg uptake of cotton grown in the soils was depicted in the Table. The Mg uptake ranged from 1.70 to 4.65, 2.05 to 5.75 and 5.23 to 10.50 kg ha^{-1} at 40,70 DAS and at harvest stage respectively. The maximum Mg uptake of 4.65, 5.75 and 10.50 kg ha^{-1} at 40,70 DAS and at harvest stage respectively were found in the treatment T_{10} which was applied with $\text{MgSO}_4 @ 50 \text{ kg ha}^{-1}$ incubated with 250 kg vermicompost for 30 days (1:5 ratio) along with N, P_2O_5 and K_2O on STCR basis. However, the minimum Mg uptake at all the three stages of crop growth (1.70, 2.05 and 5.23 kg ha^{-1}) were recorded in the treatment T_1 (RDF alone). In calcareous soil, the Mg reacts with CO_3^{2-} and OH^- and form insoluble MgCO_3 and $\text{Mg}(\text{OH})_2$. So that the availability of Mg to the labile pool get reduced. Application of MgSO_4 along with organic nutrient have released the organic acid and the organic anions which are formed during the decomposition of organic manures might have make coordinate bond with Mg supplied as MgSO_4 and the fixation of Mg as MgCO_3 and $\text{Mg}(\text{OH})_2$ would have been reduced and the availability of Mg to the labile pool got increased and easily available to the plants. Such an increase in uptake of Mg with the conjoint incorporation of N, P_2O_5 and K_2O with FYM was already reported by Mohana Rao et al., [23].

Roques et al., [24] found that adding MgSO_4 salts to spinach leaves raised Mg content by more than 53% compared to the control. Application of Mg along with organic sources only (and in combination with inorganic sources (chemical fertilizers) has resulted in maintenance of ex-Mg at optimum levels or its build-up. Inceptisols and Alfisols, with rice–lentil and finger millet based

systems, respectively, have lower CEC than the other two sites. Poor soil conditions such as soil compaction, drainage impedance and surface waterlogging, surface capping and other factors restricting root development and Mg uptake will result in symptoms of Mg deficiency rather than an absolute shortage in soil

In clay loam soil, the most effective application of Mg fertilizer increased Mg content in cotton (*Gossypium barbadense* var. Giza 75) leaves (0.67–0.82 percent), stems (0.18–0.31 percent), and roots (0.39–0.52 percent) [4]. Delfani et al., [25] found that foliar application of Mg Nano particles enhanced Mg absorption in stems and leaves of black-eyed pea (*Vigna unguiculata*) when compared to normal Mg salt, suggesting that Mg nanoparticles are more available and mobile.

3.2.6 Fe, Cu, Zn and Mn uptake

A close examination of the data pertaining to the micronutrient uptake of showed that application of Mg had a significant influence on uptake of Fe, Mn, Zn and Cu by the cotton crop. Among the various treatments, the treatment which had received $\text{MgSO}_4 @ 50 \text{ kg ha}^{-1}$ incubated with 250 kg vermicompost for 30 days (1:5 ratio) along with N, P_2O_5 and K_2O on STCR basis registered the highest Fe (1185.6, 1975.6 and 4865.2 g ha⁻¹)

¹), Mn (380.5, 530.2 and 792.3 g ha⁻¹), Zn (90.65, 155.72 and 325.60 g ha⁻¹) and Cu (90.62, 155.70 and 325.80 g ha⁻¹) uptakes at 40 DAS, 70 DAS and harvesting stages of crop. Followed by the treatment receiving $\text{MgSO}_4 @ 50 \text{ kg ha}^{-1}$ incubated with 500 kg FYM for 30 days (1:10 ratio) along with N, P_2O_5 and K_2O on basis (T₉). The lowest micro nutrient uptake was registered in T₁ (RDF alone).

Increased zinc and magnesium consumption in the field increased plant absorption of both elements and had a positive impact on traits like grain weight, hectoliter weight, and yield, according to this study. Not only did zinc and magnesium help with their own absorption, but they also helped with the absorption of other nutrients in the plant. Similar findings reported that Sadeghi et al., [26].

Ye and Chen [27] also observed the most striking effects in the form of a large increase in Mn and Zn concentrations in the leaf blades of *Citrus sinensis*, proposed the existence of antagonistic interaction between Mg, Mn, and Zn. However, in *Medicago sativa*, the antagonistic action of Mg on Mn uptake hardly existed. Which suggests that the antagonistic interaction and competitive effects of Mg on Mn vary depending on plant species, the nutrient concentration of the medium, and the cultivation type

Table 1. Effect of magnesium inconjoint with organic manures on major nutrient uptake (kg ha⁻¹) different stages of crop growth in soil

Treatment	Nitrogen			Phosphorus			Potassium		
	40 DAS	70DAS	HS	40 DAS	70 DAS	HS	40 DAS	70 DAS	HS
T ₁	5.95	9.35	20.24	1.19	2.90	5.45	12.15	18.35	28.15
T ₂	8.05	14.25	30.35	2.25	3.20	6.05	16.25	22.20	30.32
T ₃	9.12	17.30	32.13	3.02	3.60	7.54	17.80	24.25	32.30
T ₄	12.55	22.05	40.12	5.70	6.65	9.05	18.50	31.52	43.30
T ₅	12.13	21.55	39.25	5.20	6.18	8.35	18.10	31.12	42.70
T ₆	12.20	21.86	39.75	5.45	6.40	8.70	18.35	31.30	43.05
T ₇	11.60	20.84	37.64	4.90	5.80	8.00	17.35	29.80	40.75
T ₈	11.07	20.20	37.15	4.65	5.36	7.65	16.63	28.50	38.80
T ₉	13.50	22.90	42.02	6.10	7.25	9.90	19.56	33.18	45.50
T ₁₀	14.25	23.60	43.50	6.25	7.80	10.34	20.35	34.50	47.45
T ₁₁	10.16	19.02	35.18	3.38	4.15	6.75	16.02	26.86	36.20
T ₁₂	10.34	19.24	35.40	3.55	4.50	7.05	16.14	27.06	36.55
T ₁₃	10.55	19.50	35.65	3.80	4.90	7.35	16.30	27.18	36.90
T ₁₄	12.74	22.22	40.50	5.90	6.90	9.42	18.80	31.75	43.56
T ₁₅	9.60	18.30	33.70	3.12	3.83	6.35	15.30	25.50	34.25
SEd±	0.25	0.32	0.70	0.06	0.08	0.15	0.33	0.62	0.88
CD(P=0.05)	0.52	0.67	1.45	0.15	0.19	0.34	0.70	1.30	1.90

SEd- Standard error deviation, CD- Critical deviation

Table 2. Effect of magnesium inconjoint with organic manures on secondary nutrient uptake (kg ha^{-1}) different stages of crop growth in soil

Treatment	Calcium uptake			Magnesium uptake		
	40 DAS	70 DAS	HS	40 DAS	70 DAS	HS
T ₁	12.35	14.22	43.25	1.70	2.05	5.23
T ₂	14.90	18.61	48.31	1.90	2.40	6.10
T ₃	15.55	22.10	50.45	2.03	2.85	6.30
T ₄	18.40	23.15	62.65	3.70	4.60	8.95
T ₅	18.02	29.80	61.82	3.30	4.20	8.82
T ₆	18.16	30.05	62.05	3.50	4.40	8.90
T ₇	17.22	28.50	59.60	3.10	4.02	8.38
T ₈	16.42	27.18	57.40	2.90	3.85	8.05
T ₉	19.51	31.90	65.35	4.10	5.20	9.42
T ₁₀	20.54	33.21	69.21	4.65	5.75	10.50
T ₁₁	15.21	25.05	54.85	2.35	3.25	7.07
T ₁₂	15.35	25.45	55.10	2.52	3.45	7.40
T ₁₃	15.60	25.80	55.30	2.70	3.65	7.65
T ₁₄	18.65	30.60	63.10	3.90	4.82	9.05
T ₁₅	16.42	24.35	52.70	2.20	3.03	6.75
SEd±	0.37	0.63	1.07	0.07	0.08	0.15
CD (P=0.05)	0.77	1.30	2.21	0.15	0.17	0.32

SEd- Standard error deviation, CD- Critical deviation

Table 3. Effect of magnesium inconjoint with organic manures on micro nutrient uptake (g ha⁻¹) different stages of crop growth in soil

Treatment	Iron uptake			Manganese uptake			Zinc uptake			copper uptake		
	40 DAS	70DAS	HS	40 DAS	70DAS	HS	40 DAS	70DAS	HS	40 DAS	70DAS	HS
T ₁	635.2	985.5	3672.5	140.5	203.5	384.2	35.10	46.82	102.31	36.58	36.56	101.35
T ₂	818.5	1132.6	4087.3	183.2	260.4	428.5	52.40	72.36	153.48	52.85	73.45	150.52
T ₃	845.0	1225.3	4279.5	188.6	284.2	473.1	60.15	92.45	157.50	57.72	91.50	194.65
T ₄	1070.5	1725.3	4410.6	330.2	440.4	708.9	82.70	141.78	294.73	81.48	141.50	292.54
T ₅	1052.4	1670.2	4314.8	306.5	404.1	657.4	79.80	139.20	288.50	78.42	138.45	288.10
T ₆	1060.8	1690.5	4360.5	318.3	421.2	683.4	80.48	140.69	291.25	80.62	139.52	290.25
T ₇	1015.5	1589.7	4463.5	285.4	385.5	631.2	76.18	133.25	266.43	74.70	136.74	275.50
T ₈	975.5	1510.8	4425.7	260.3	367.2	605.8	72.50	127.35	270.18	71.56	134.71	264.35
T ₉	1125.4	1850.4	4642.4	365.7	505.8	763.2	87.02	148.25	308.45	86.12	148.30	310.52
T ₁₀	1185.6	1975.6	4865.2	380.5	530.2	792.3	90.65	155.72	325.60	90.62	155.70	325.80
T ₁₁	925.3	1380.1	4358.1	216.5	312.1	525.4	66.12	120.70	248.18	78.45	130.40	247.45
T ₁₂	930.1	1408.4	4387.2	225.4	330.4	552.5	67.64	121.26	252.40	64.64	131.62	250.75
T ₁₃	938.6	1430.2	4409.3	240.3	348.4	578.1	69.00	121.45	255.20	66.35	133.30	252.40
T ₁₄	1085.1	1752.6	4442.3	345.2	460.2	734.8	83.40	142.25	297.12	67.25	143.25	299.30
T ₁₅	888.4	1300.4	4312.6	203.5	303.5	502.8	63.51	115.36	238.70	60.25	127.35	236.25
SEd±	17.40	38.65	95.80	4.45	8.30	12.10	1.75	2.82	4.84	1.83	2.41	5.41
CD(P=0.05)	35.60	79.30	198.42	9.17	17.20	25.40	3.60	5.82	9.98	3.78	4.97	11.14

*SEd- Standard error deviation, CD- Critical deviation

Table 4. Effect of magnesium inconjoint with organic manures on yield attributes of cotton

S.No	Treatment	Seed Cotton yield (q ha ⁻¹)
1	T ₁ – Recommended N, P ₂ O ₅ and K ₂ O @ 80:40:40 kg ha ⁻¹	17.50
2	T ₂ – N, P ₂ O ₅ and K ₂ O on STCR basis	18.65
3	T ₃ – T ₂ + Basal application of MgSO ₄ @ 37.5 kg ha ⁻¹	19.50
4	T ₄ – T ₂ + MgSO ₄ @ 37.5 kg ha ⁻¹ incubated with 375 kg FYM for 30 days (1:10 ratio)	24.05
5	T ₅ – T ₂ + MgSO ₄ @ 25 kg ha ⁻¹ incubated with 250 kg FYM for 30 days (1:10 ratio)	23.22
6	T ₆ – T ₂ + MgSO ₄ @ 37.5 kg ha ⁻¹ incubated with 187.5 kg VC for 30 days (1:5 ratio)	23.62
7	T ₇ – T ₂ + MgSO ₄ @ 25 kg ha ⁻¹ incubated with 125 kg VC for 30 days (1:5 ratio)	22.25
8	T ₈ – T ₂ + Basal application of MgSO ₄ @ 50 kg ha ⁻¹	21.35
9	T ₉ – T ₂ + MgSO ₄ @ 50 kg ha ⁻¹ incubated with 500 kg FYM for 30 days (1:10 ratio)	25.20
10	T ₁₀ – T ₂ + MgSO ₄ @ 50 kg ha ⁻¹ incubated with 250 kg VC for 30 days (1:5 ratio)	26.25
11	T ₁₁ – T ₂ + Foliar application of MgSO ₄ @ 1 % on 20,40,60 DAS	20.05
12	T ₁₂ – T ₃ + Foliar application of MgSO ₄ @ 1 % on 20,40,60 DAS	20.23
13	T ₁₃ – T ₈ + Foliar application of MgSO ₄ @ 1 % on 20,40,60 DAS	20.36
14	T ₁₄ – T ₂ + Basal application of EDTA @ 2 kg ha ⁻¹	24.31
15	T ₁₅ – T ₂ + Foliar application of Mg EDTA @ 0.5% on 20 40 60 DAS	19.76
	SEd±	0.44
	CD(P=0.05)	0.91

Similarly application of vermicompost significantly increased the uptake of Fe, Mn, Zn and Cu by the crop. Higher uptake of micronutrients by combined addition of Mg and organics might be due to the release of micronutrients on mineralization organics upon decomposition, which aids in solubilization of insoluble micronutrient compounds in soil or due to supply of natural chelating agents, which renders them more available. The chelating action of released organic compounds prevent the micronutrient cations from fixation, precipitation, oxidation and leaching and increase their availability and uptake by plants. This is in accordance with results of Devarajan et al. [28] and Gogoi et al. [29].

4. CONCLUSION

The results clearly showed that application of magnesium along with organic manures especially vermicompost followed by FYM can be recommended for cotton cultivation in at Virudhunagar district due to the highest nutrient uptake observed while applying of MgSO₄ @ 50 kg ha⁻¹ incubated with 250 kg vermicompost for 30 days (1:5 ratio) along with N, P₂O₅ and K₂O on STCR based.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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