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# Positive and Negative Soil Relations in Intensive Tomato Cultivation in the Eastern Dry Zone of Karnataka, India

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**Abstract**

Over exploitation of nutrients in the eastern dry zone of Karnataka has had an adverse effect on the natural environment, highlighting the need for research on soil characteristics and their influence on the cultivation of tomatoes. The objective of the study was to assess the pros and cons of different soil properties for the intensive farming of tomatoes in Karnataka's eastern dry zone. The present study analysed the effects of annual tomato cultivation, which cultivated once, twice and three times a year on the correlation between soil physical, chemical and biological properties in intensively cultivated soils in Karnataka, India. By using SPSS and XLSTAT for correlation was assessed. it was found positive correlations between soil properties and 19 soil parameters indicators out of 26 parameters, including exchangeable Mg and volume of expansion. However, it also an inverse correlation between 07 soil properties in intensive cultivation of tomato. By implementing appropriate soil management strategies, farmers can mitigate the adverse effects of nutrient over exploitation and ensure sustainable tomato cultivation in the region.

*Keywords* : Correlation, Soil properties, Tomato, Intensive cultivation

Intensive tomato cultivation involves maximizing soil interactions for plant growth, crop yield and fruit quality. Start by conducting a thorough soil analysis to evaluate nutrient levels (Sanchez and Swaminathan, 2005), pH and organic matter content. Adjust the soil based on the results to optimize nutrient levels and pH. Use organic amendments like compost and manure to enhance soil structure and fertility (Chang *et al*., 2007). Implement crop rotation and cover crops to disrupt disease cycles and improve soil fertility. Utilize organic mulches to retain moisture, control weeds and regulate soil temperature (Azarmi *et al.,* 2008). Install drip irrigation systems to minimize water wastage and foliar diseases. Monitor soil moisture levels and adjust irrigation schedules accordingly. Minimize soil disturbance and promote diverse microbial populations for soil health. Apply fertilizers judiciously based on soil nutrient deficiencies and plant requirements. Use slow-release or organic fertilizers to reduce leaching and runoff. Optimize soil interactions through targeted soil management.

Intensive tomato cultivation in dry zones has both benefits and drawbacks. High-density planting and controlled irrigation can lead to higher crop yields per unit area, maximizing production in limited arable land. Drip irrigation reduces water wastage, making efficient water usage crucial in regions with scarce water resources. Intensive cultivation utilizes technology and inputs like fertilizers, enhancing resource utilization efficiency (Barche *et al.,* 2011). Mechanization and automation decrease labour demands, making production economically feasible in areas with high labour costs or limited availability. Intensive systems allow for closer monitoring of crops, aiding in early detection and control of pests and diseases, reducing yield losses. Intensive farming methods require significant upfront investment in infrastructure, technology and resources. This can deter small-scale farmers or those with limited finances. Improper management can lead to soil degradation, especially in regions with fragile soils. Intensive farming relies heavily on external resources like water and energy, which can exacerbate droughts or water scarcity in arid regions. Excessive use of fertilizers and pesticides can contaminate water sources and degrade soil quality (Afolabi *et al.,* 2017). Inadequate handling of agricultural chemicals can harm ecosystems and human health. Intensive farming is more susceptible to crop failures due to pests, diseases and extreme weather events, particularly in arid regions. While intensive tomato farming in arid regions offers benefits, careful management is necessary for long-term sustainability. Strategies that prioritize soil health, water conservation and ecological resilience are crucial for minimizing adverse effects.

Intensive tomato cultivation can impact soil properties positively by adding organic amendments like compost or manure to enhance soil fertility (Ewulo *et al.,* 2008). This increases soil organic matter, improving soil structure, water retention and nutrient cycling. Regular fertilization meets high nutrient demands of tomato plants, replenishing essential nutrients and maintaining balance (Deepak *et al*. 2020). Reduced tillage and cover crops promote soil aggregation and porosity, enhancing water infiltration, root penetration and gas exchange for healthy plant growth. Minimizing soil disturbance through practices like no-till or minimum tillage can reduce soil erosion, especially in dry zones with limited vegetation and high wind speeds (John *et al.,* 2019).

Intensive cultivation practices, like heavy machinery and repeated cultivation can lead to soil compaction in fine-textured soils. This reduces pore space, hindering root growth, water infiltration and nutrient uptake, impacting plant growth and soil health. Overuse of fertilizers can cause nutrient imbalances and disrupt soil pH levels, affecting nutrient cycling and increasing pollution. Intensive irrigation can lead to soil salinization, impeding plant growth and decreasing yields (Saikumar and Nagendra Rao 2016). Frequent soil disturbance can decrease soil organic matter, reducing fertility and increasing erosion. These practices can contribute to soil degradation, reducing productivity and resilience in arid regions. Sustainable intensification methods that prioritize soil health and conservation practices are essential for long-term productivity and sustainability in intensive tomato cultivation (Salahin *et al*., 2011: Ananthakumar and Meghana, 2022).

Soil characteristics may display different relation ships based on variables such as soil type, climate, land use and management techniques. Various connections between soil properties exist, such as how soil texture impacts drainage - sandy soils drain faster due to larger pore spaces, while clay soils drain slower due to smaller pore spaces. The presence of organic matter affects soil fertility by enhancing nutrient retention, water holding capacity and microbial activity. Soils with higher organic matter content are generally more fertile. Soil pH plays a role in nutrient availability; acidic soils may have higher aluminium and manganese toxicity, while alkaline soils can limit the availability of micronutrients like iron and zinc. CEC indicates the soil's capacity to retain and exchange positively charged ions (cations) like calcium, magnesium, potassium and ammonium. Soils with higher CEC typically have better nutrient retention capabilities. Bulk density, influenced by soil compaction, is the mass of soil per unit volume (Colla *et al.,* 2008). Compacted soils have higher bulk density, which can hinder root growth, water infiltration and aeration. Soil texture also affects water holding capacity, with clay soils retaining more water due to smaller pore spaces compared to sandy soils. Soil colour can impact temperature, as darker soils absorb more solar radiation and warm up faster than lighter-coloured soils. These relationships are crucial in soil management and agriculture, influencing crop productivity, water management and environmental sustainability (Brzezinska *et al.,* 1998). It is important to note that soil properties interact in complex ways and correlations can vary based on specific local conditions and management practices. Under standing these connections can aid in soil management and agricultural practices, enabling adjustments to optimize soil conditions for plant growth and productivity.

Karnataka, specifically Kolar and Chickballapur districts, is a major tomato producer, yielding around 4,00,000 tons annually. Chintamani, in Chickballapur is famous for its silk, milk and tomato production, boasting the largest markets in the state. The area benefits from a hot and dry climate, sufficient rainfall and potassium-rich soil. Farmers in Chintamani grow tomatoes in small plots during kharif, moderately during rabi and extensively in the summer. They use mulching techniques and practice three crop rotations per year on the same land. However, improper use of nutrients, chemicals will harm the soil in heavily cultivated tomato fields. An investigation was conducted to study the impact of continuous tomato cultivation on soil through positive and negative correlation between the soil properties.

## Material and Methods

The research site is located in south eastern Karnataka, India on the Deccan Plateau. It covers an area of 867 square kilometres and is GPS between 13°16' to 13°42'N latitude and 77° 51' to 78' 12'E longitude. Chintamani has a tropical semi-arid climate with hot and dry weather conditions. Summer maximum temperatures can reach up to 38°C and the average annual rainfall ranges from 400 to 750 mm. Most of the rainfall occurs during the South West Monsoon

**Table 1**

**Meteorological data of Chintamani taluk during 2021-22**

| Month | RF *(mm) | MaxTemp (°C) | MinTemp (°C) | RH I (%)* | RH II (%)* |
|---|---|---|---|---|---|
| Jan | 16.81 | 27.92 | 17.01 | 83.77 | 80.19 |
| Feb | 27.20 | 29.89 | 15.84 | 73.64 | 65.86 |
| Mar | 0.00 | 33.99 | 17.72 | 61.42 | 53.29 |
| Apr | 41.70 | 35.22 | 19.54 | 66.07 | 58.67 |
| May | 87.20 | 34.46 | 21.16 | 70.32 | 66.23 |
| Jun | 64.30 | 30.87 | 20.81 | 75.73 | 66.20 |
| Jul | 196.00 | 29.27 | 20.39 | 83.23 | 73.35 |
| Aug | 251.30 | 29.17 | 20.16 | 81.35 | 70.26 |
| Sep | 177.60 | 29.62 | 20.20 | 80.17 | 68.97 |
| Oct | 504.50 | 28.99 | 19.79 | 82.48 | 71.10 |
| Nov | 285.42 | 25.93 | 19.04 | 89.97 | 83.33 |
| Dec | 14.80 | 26.99 | 15.17 | 84.97 | 68.48 |
| Mean | 138.90 | 30.19 | 18.90 | 77.76 | 68.83 |
| SD | 151.44 | 2.95 | 1.99 | 8.46 | 8.17 |
| CV (%) | 91.72 | 1023.65 | 948.98 | 918.65 | 842.24 |
| Min | 0.00 | 25.93 | 15.17 | 61.42 | 53.29 |
| Max | 504.50 | 35.22 | 21.16 | 89.97 | 83.33 |

* RF = Rain fall, * RH = Relative Humidity


Fig. 1 : Map of the study area

and North East Monsoon seasons, with the highest amount in the month October and November (Table 1 and Fig. 2). The region is classified as the Eastern Dry Zone of Karnataka (Fig. 1). The soil composition in the area is Sandy Clay Loam (SCl), which is suitable for growing mulberry, cereals, vegetables and pulses. Tomato cultivation is prominent and finger millet is intercropped with red gram and field bean during the *kharif* season. Maize is grown during the rabi season and irrigation is used for mulberry, groundnut and vegetable cultivation.

Ninety soil samples were collected from extensively cultivated tomato soils in the Kasaba cluster of Chintamani in order to conduct analysis (30 samples yearly one time, 30 samples yearly two times and 30 samples yearly three times tomato growing soils). GPS tools were employed to ensure precise sample collection. Standard methods as described by

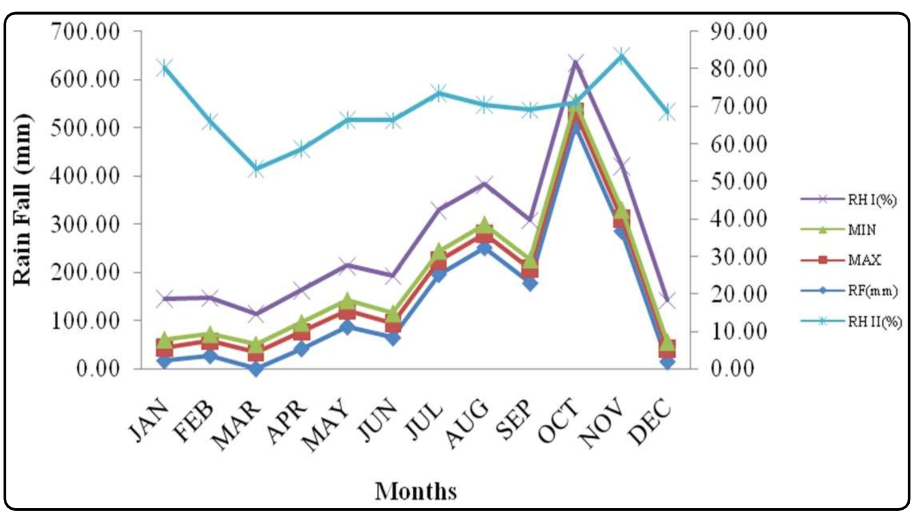


Fig. 2 : Weather data of Chintamani taluk during 2021-22

Jackson, 1973 were adopted for the analysis of the soil samples. Particle sizes distribution was determined by Bouycous hydrometer method (Bouyoucos, 1936), Bulk density and moisture content by gravimetric method (as expressed by the weight of the soil before and after over-dried and the volume of the soil), by keen's cup method (Piper, 1966). The soil pH in water (1:2.5) was determined using potentiometric analysis using glass electrode pH meter. Conductivity cell is used for estimation of EC of soil water suspension, Organic matter content was determined by (Walkey-Black, 1934) wet digestion method. The available N of soil was distilled with 25 mL of 0.32 per cent $KMnO_4$ and 25 mL of 2.5 per cent sodium hydroxide (NaOH). The liberated ammonia was trapped in 4 per cent $H_3BO_3$ containing bromo-cresol green and methyl red mixed indicator and titrated against standard sulfuric acid (Subbiah and Asija 1956) Available $P_2O_5$ in soil samples were extracted with Bray's-1 ($NH_4F$+HCl) and Olsen's Method (0.5 M $NaHCO_3$). Phosphorus content in the extract was determined by ascorbic acid-molybdate complex method and the blue colour intensity was recorded at 660 nm using spectrophotometer (Jackson 1973). The exchangeable cations were extracted with 1M $NH_4OAC$ (pH 7.0) to determine K using flame photometer and exchangeable Ca and Mg by ion complex with EDTA solution while available sulphur was estimated by using Turbidometry method. Micronutrient cations (Fe, Mn, Cu and Zn) are extracted with DTPA and estimated by atomic absorption spectrophotometer (Lindsay and Norell, 1978) and Hot water-soluble boron was estimated by colour development with azomethane and intensity was recorded at 430 nm using spectrophotometer (Jackson 1973). Dehydrogenase activity in the soil was measured using spectrophoto metry. Dehydrogenase activity was reported as µg TPF $g^{-1}$ soil material $hr^{-1}$. The colorimetric estimation of acid and alkaline phosphatase activity was conducted using the method outlined by Tabatabai and Bremner (1969). Two sets of 1g soil samples were placed in 50 mL centrifuged tubes, with one set serving as the control. Toluene and modified universal buffer (MUB) at pH 6.5 were added to all the tubes. One set of samples had P-nitrophenyl phosphate added as a substrate. The tubes were gently swirled and incubated at 37°C for one hour. After incubation, $CaCl_2$ and NaOH were added and briefly swirled. The suspensions were filtered and the yellow colour intensity of the filtrates was measured at a wavelength of 440 nm. The amount of p-nitrophenol formed in each sample was determined using a standard curve. The acid phosphatase activity was expressed as µg p-nitrophenol released per gram of soil per hour. The urease activity in the soil was assessed using the method proposed by Tabatabai and Bremmer (1972). This involved measuring the amount of $NH_4$ released during the assay. To conduct the assay, 5 g of soil (< 2 mm) was placed in a 50 ml volumetric flask with the assay medium. The assay medium consisted of 0.2 mL of toluene, 5 mL of THAM buffer (pH 9.0, 0.05 M) and 1 mL of urea (0.2 M). The reaction mixture was incubated at 37°C for 2 hours for urea hydrolysis. After incubation, a KCl-Ag, $SO_4$ solution was added to stop the enzymatic reaction. The resulting content was extracted multiple times to measure the release of ammonia. The $NH_4$-N in the soil suspension was determined through distillation and the urease activity in the soil was expressed as mg $NH_4$ -N per 100 g of soil per hour. Halvorsun and Zeiglar's (1993) approach for studying microbial populations in tomato cultivation soils was modified by Chhonkar *et al.* (2007) to quantify CFU per gram of soil. Bacteria, fungi and actinomycetes were quantified using the serial dilution pour plate method with specific media from (Nutrient agar medium for Bacteria, Martin's rose Bengal agar for Fungi and Kusters agar for Actinomycetes). Three plates per sample and microbial group were incubated at 28 ± 1°C for one week. The population of each group was determined using a colony counter and recorded as CFU per gram of dry soil. The statistical analysis will involve calculating correlations using the standard method provided by Panse and Sukhatme (1967) and conducted using Stastical

### Table 2 (a)

**Pearson correlation between soil quality indicators and yearly one time tomato growing soils**

| | pH | EC | OC | AK | Ca | Mg | AS | Zn | Cu | Fe | Mn | MWHC | VE | APA2 | AAP1 | SMF | TB | TF | TA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 1 | | | | | | | | | | | | | | | | | | |
| EC | 0.638 | 1 | | | | | | | | | | | | | | | | | |
| OC | 0.074 | 0.243 | 1 | | | | | | | | | | | | | | | | |
| AK | 0.481 | 0.275 | 0.042 | 1 | | | | | | | | | | | | | | | |
| Ca | 0.2 | 0.183 | 0.595 | 0.148 | 1 | | | | | | | | | | | | | | |
| Mg | 0.121 | 0.257 | 0.58 | 0.148 | 0.773 | 1 | | | | | | | | | | | | | |
| AS | 0.341 | 0.356 | 0.458 | 0.167 | 0.314 | 0.227 | 1 | | | | | | | | | | | | |
| Zn | 0.224 | 0.291 | 0.329 | 0.051 | 0.429 | 0.169 | 0.228 | 1 | | | | | | | | | | | |
| Cu | 0.322 | 0.06 | 0.1 | 0.215 | 0.051 | -0.138 | -0.267 | 0.389 | 1 | | | | | | | | | | |
| Fe | -0.351 | -0.105 | -0.294 | -0.142 | -0.23 | -0.343 | -0.428 | 0.204 | 0.198 | 1 | | | | | | | | | |
| Mn | -0.323 | -0.22 | -0.206 | -0.193 | -0.218 | -0.313 | -0.312 | -0.068 | 0.087 | 0.442 | 1 | | | | | | | | |
| MWHC | 0.348 | 0.458 | 0.284 | 0.362 | 0.323 | 0.151 | 0.285 | 0.362 | 0.163 | 0.074 | -0.283 | 1 | | | | | | | |
| VE | 0.301 | 0.368 | 0.007 | 0.126 | 0.149 | -0.021 | 0.236 | 0.39 | 0.19 | 0.239 | -0.274 | 0.709 | 1 | | | | | | |
| AAP1 | 0.011 | 0.102 | -0.085 | 0.138 | -0.166 | -0.311 | -0.266 | 0.129 | 0.402 | 0.29 | 0.238 | 0.397 | 0.263 | 1 | | | | | |
| APA2 | 0.28 | 0.244 | 0.008 | 0.302 | 0.02 | -0.051 | 0.037 | 0.26 | 0.399 | -0.044 | -0.125 | 0.603 | 0.318 | 0.643 | 1 | | | | |
| SMF | 0.095 | -0.158 | 0.466 | 0.125 | 0.377 | 0.33 | 0.517 | 0.228 | -0.141 | -0.284 | -0.198 | -0.261 | -0.074 | -0.433 | -0.255 | 1 | | | |
| TB | -0.134 | -0.031 | 0.354 | -0.049 | 0.296 | 0.354 | 0.192 | 0.197 | -0.132 | -0.273 | 0.053 | -0.124 | -0.219 | 0.014 | 0.002 | 0.367 | 1 | | |
| TF | -0.169 | -0.086 | 0.096 | -0.111 | 0.131 | 0.173 | -0.188 | -0.107 | -0.028 | -0.142 | 0.25 | 0.068 | -0.439 | 0.199 | 0.085 | -0.208 | 0.424 | 1 | |
| TA | 0.434 | 0.399 | -0.008 | 0.385 | 0.092 | 0.212 | 0.12 | 0.386 | 0.238 | 0.102 | -0.321 | -0.087 | 0.328 | -0.254 | 0.116 | 0.187 | -0.215 | -0.382 | 1 |

*EC- Electrical conductivity, *OC– Organic carbon, *AK– Available potassium,*Ca- Exchangeable calcium, *Mg- Exchangeable Magnesium, *AS-Available sulphur, *Zn-DTPA extractable zinc, *Cu-DTPA extractable copper, *Fe- DTPA extractable iron, * Mn-DTPA extractable manganese, *MWHC-Maximum water holding capacity, *VE-Volume of expansion, *AAP1-Acid phosphatase activity, *AAP2-Alkali phosphatase activity, *SMF-Soil micro-fauna, *TB-Total bacteria, *TF-Total fungi, *TA-Total actinomycetes

Package for Social Science (SPSS) (Version 18.0) and Microsoft XL (XLSTAT software).

## Results and Discussion

### Positive Correlation Between Soil Properties in Yearly One Time Tomato Growing Soils

A correlation analysis was conducted on the soil properties in soils used for yearly one-time tomato cultivation, revealing a positive correlation between 19 soil quality indicators and soil properties (Table 2a). A partial correlation was then performed to explore the relationship between each individual soil quality indicator and the other 19 parameters considered in the study. Notably, exchangeable Mg (r = 0.773) and volume of expansion (r = 0.703) exhibited a strong positive correlation with the soil properties in soils used for yearly one-time tomato cultivation. The pH of the soil samples showed a positive correlation with EC (r = 0.63), which was statistically significant at a 5 per cent level of significance across all sample observations.

Additionally, the pH was significantly positively correlated with available potassium (r = 0.481) and actinomycetes activities (r = 0.434) similar findings was noticed by (Ranjith *et al.,* 2016) in cotton. Furthermore, the electrical conductivity of the soil samples was positively correlated with MWHC (r = 0.458), while it showed a non-significant positive correlation with acid phosphatase enzyme activity (r = 0.102). Organic carbon in the soil samples displayed a significant positive correlation with exchangeable calcium (r = 0.59), exchangeable Mg (r = 0.588), available Sulphur (r = 0.458) and micro-fauna (r = 0.46). On the other hand, exchangeable Ca exhibited a highly significant positive correlation with exchangeable Mg (r = 0.773) and a significant positive correlation with DTPA Zn (r = 0.429). Available Sulphur in the soil samples was significantly correlated with micro-fauna (r = 0.517) at a 5 per cent level of significance, while DTPA Cu showed a significant positive correlation with acid phosphatase (r = 0.402). Similarly, DTPA Fe was significantly correlated with DTPA Mn (r = 0.442) at a 5 per cent level of significance.

### Negative Correlation between Soil Properties in Yearly One Time Tomato Growing Soils

There was an inverse correlation observed among soil properties in soils used for tomato cultivation on a yearly basis (Table 2b). The bulk density of soil samples exhibited a negative association with

Table 2 (b)

**Pearson correlation between soil properties in yearly one time tomato growing soils**

| | AS | Fe | BD | MWHC | VE | Urease | DHA | AAP1 | SMF | TF |
|---|---|---|---|---|---|---|---|---|---|---|
| AS | 1 | | | | | | | | | |
| Fe | -0.428 | 1 | | | | | | | | |
| BD | -0.006 | -0.165 | 1 | | | | | | | |
| MWHC | 0.285 | 0.074 | -0.433 | 1 | | | | | | |
| VE | 0.235 | 0.239 | -0.285 | 0.709 | 1 | | | | | |
| Urease | 0.199 | -0.534 | 0.352 | -0.262 | -0.285 | 1 | | | | |
| DHA | 0.189 | -0.499 | 0.077 | 0.066 | -0.162 | 0.388 | 1 | | | |
| AAP1 | -0.266 | 0.29 | 0.088 | 0.397 | 0.263 | -0.144 | 0.114 | 1 | | |
| SMF | 0.517 | -0.284 | 0.227 | 0.044 | -0.074 | 0.259 | -0.078 | -0.433 | 1 | |
| TF | -0.188 | -0.142 | 0.213 | -0.217 | -0.439 | 0.399 | 0.254 | 0.199 | 0.424 | 1 |

*AS-Available sulphur, *Fe-DTPA extractable iron, *BD-Bulk density, *MWHC-Maximum water holding capacity, *VE-Volume of expansion, *Urease-Urease activity, *DHA-Dehydrogenase activity, *AAP1-Acid phosphatase activity, *SMF-Soil micro-fauna, *TF-Total fungi

**TABLE 3 (a)**

**Pearson correlation between soil quality indicators and yearly two times tomato growing soils**

| | pH | EC | OC | AN | AP | AK | Ca | Mg | Zn | Cu | Fe | Mn | B | MWHC | VE | Urease | DHA | AAP1 | AAP2 | SMF | TB | TF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 1 | | | | | | | | | | | | | | | | | | | | | |
| EC | 0.359 | 1 | | | | | | | | | | | | | | | | | | | | |
| OC | 0.138 | 0.25 | | | | | | | | | | | | | | | | | | | | |
| AN | 0.025 | 0.293 | 0.129 | 1 | | | | | | | | | | | | | | | | | | |
| AP | 0.326 | 0.457 | 0.358 | 0.583 | 1 | | | | | | | | | | | | | | | | | |
| AK | 0.369 | 0.432 | 0.475 | 0.281 | 0.172 | 1 | | | | | | | | | | | | | | | | |
| Ca | 0.524 | 0.367 | 0.088 | 0.129 | 0.14 | 0.544 | 1 | | | | | | | | | | | | | | | |
| Mg | 0.484 | 0.353 | -0.06 | -0.145 | 0.068 | 0.202 | 0.734 | 1 | | | | | | | | | | | | | | |
| Zn | -0.033 | -0.134 | 0.058 | -0.068 | 0.251 | -0.118 | -0.099 | -0.145 | 1 | | | | | | | | | | | | | |
| Cu | 0.062 | -0.165 | 0.087 | -0.142 | 0.142 | -0.17 | -0.101 | -0.061 | 0.462 | 1 | | | | | | | | | | | | |
| Fe | -0.135 | -0.242 | -0.066 | -0.085 | -0.094 | -0.098 | 0.043 | 0.182 | 0.03 | 0.336 | 1 | | | | | | | | | | | |
| Mn | -0.135 | -0.242 | -0.066 | -0.085 | -0.094 | -0.098 | 0.043 | 0.182 | 0.03 | 0.336 | 1 | 1 | | | | | | | | | | |
| B | 0.177 | 0.179 | 0.422 | 0.145 | 0.251 | 0.496 | 0.016 | -0.049 | 0.009 | 0.096 | -0.096 | -0.022 | 1 | | | | | | | | | |
| MWHC | 0.358 | 0.283 | 0.128 | 0.209 | 0.142 | 0.522 | 0.686 | 0.375 | 0.046 | 0.232 | 0.232 | 0.167 | 0.257 | 1 | | | | | | | | |
| VE | 0.13 | 0.174 | 0.08 | 0.271 | 0.057 | 0.227 | 0.579 | 0.404 | 0.201 | 0.054 | 0.054 | 0.069 | -0.099 | 0.652 | 1 | | | | | | | |
| Urease | -0.62 | 0.14 | -0.058 | -0.042 | 0.16 | -0.014 | 0.046 | 0.209 | -0.165 | 0.076 | 0.076 | 0.082 | 0.066 | 0.156 | 0.152 | 1 | | | | | | |
| DHA | 0.425 | 0.347 | -0.048 | 0.122 | 0.128 | 0.331 | 0.581 | 0.688 | -0.411 | -0.219 | -0.219 | -0.111 | -0.047 | 0.32 | 0.522 | 0.199 | 1 | | | | | |
| AAP1 | 0.173 | 0.18 | 0.03 | 0.215 | 0.012 | 0.139 | 0.241 | 0.035 | -0.057 | 0.113 | 0.113 | 0.305 | -0.036 | 0.539 | 0.247 | -0.034 | -0.188 | 1 | | | | |
| AAP2 | 0.351 | 0.144 | 0.252 | 0.164 | 0.147 | 0.474 | 0.409 | 0.111 | 0.019 | 0.193 | 0.193 | 0.319 | 0.298 | 0.632 | 0.238 | 0.071 | -0.127 | 0.797 | 1 | | | |
| SMF | 0.326 | 0.086 | 0.552 | 0.066 | 0.137 | 0.381 | 0.172 | 0.017 | 0.11 | 0.26 | 0.26 | -0.031 | 0.202 | 0.322 | 0.154 | 0.001 | 0.193 | 0.016 | 0.185 | 1 | | |
| TB | 0.341 | 0.219 | 0.089 | 0.234 | 0.087 | 0.277 | 0.262 | 0.216 | -0.323 | 0.076 | 0.076 | -0.177 | -0.055 | 0.354 | 0.244 | 0.193 | 0.4 | 0.262 | 0.252 | 0.121 | 1 | |
| TF | 0.27 | 0.096 | -0.26 | -0.092 | -0.156 | -0.084 | 0.057 | 0.049 | -0.091 | 0.01 | 0.01 | -0.33 | -0.063 | 0.097 | 0.038 | -0.399 | 0.009 | 0.489 | 0.296 | -0.115 | 0.237 | 1 |

*EC- Electrical conductivity, *OC– Organic carbon, *AK– Available potassium, * Ca- Exchangeable calcium, *Mg- Exchangeable Magnesium, *AS-Available sulphur, *Zn-DTPA extractable zinc, *Cu-DTPA extractable copper, *Fe- DTPA extractable iron, * Mn-DTPA extractable manganese, *MWHC-Maximum water holding capacity, *VE-Volume of expansion, *AAP1-Acid phosphatase activity, *AAP2-Alkali phosphatase activity, *SMF-Soil micro-fauna, *TB-Total bacteria, *TF-Total fungi, *TA-Total actinomycetes.

maximum water holding capacity (r = -0.433) and a non-significant negative correlation with volume of expansion (r = -0.288). Furthermore, the volume of expansion of soil samples was significantly negatively correlated with fungi population (r = -0.439), while Acid phosphates activities showed a negative relationship with micro-fauna (r = -0.433) at a 5 per cent level of significance. Mishra (2005) stated that soil productivity can be certainly be lost through land degradation, erosion, nutrient mining or other processes such as salinization, sodification, compaction and water logging. The linkage between soil productivity and its quality is apparent when changes in soil attributes used to assess soil quality are linked to causes of productivity loss. The effects of management practices on productivity can also be assessed using soil quality attributes.

**Positive Correlation between Soil Properties in Yearly Two Times Tomato Growing Soils**

The information provided in Table 3(a) displays the positive correlation coefficients between various soil quality indicators in soils used for growing tomatoes twice a year in the Kasaba cluster of Chintamani taluk. The results clearly show that soil pH is significantly and positively correlated with Ca (r= 0.524), Mg (r= 0.484) and DHA (r= 0.425), and also significantly correlated with AK (r= 0.369). Soil EC is highly significant and positively correlated with available P (r= 0.457), AK (r =0.432) and significantly correlated with Ca (r =0.367) at a 5 per cent level of significance. Organic carbon is highly significant and positively correlated with SMF (r = 0.552) and significantly correlated with AK (r = 0.475) and B (r = 0.422). AN is highly significant and positively correlated with AP (r = 0.583). AK content is positively correlated and highly significant with Ca (r = 0.544), B (r = 0.496), AAP2 (r = 0.474) and SMF (r = 0.381) at a 5 per cent level of significance. Ca is highly significant and positively correlated with Mg (r = 0.779), DHA (r = 0.581) and AAP2 (r = 0.409). On the other hand, Mg is significantly and positively correlated with MWHC (r = 0.375), VE (r = 0.404) and DHA (r = 0.688). A positive correlation between Zn and Cu (r = 0.462) was observed in the soils used for growing tomatoes twice a year. Similarly, MWHC is highly positively

**Table 3 (b)**

**Pearson correlation between soil properties in yearly two-time tomato growing soils**

| | pH | BD | Ca | AN | AS | Zn | Urease | DHA | SMF | TF | TA |
|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 1 | | | | | | | | | | |
| BD | -0.389 | 1 | | | | | | | | | |
| Ca | 0.524 | -0.475 | 1 | | | | | | | | |
| AN | 0.025 | -0.15 | 0.129 | 1 | | | | | | | |
| AS | 0.091 | 0.173 | 0.073 | -0.511 | 1 | | | | | | |
| Zn | -0.033 | 0.198 | -0.099 | -0.068 | 0.178 | 1 | | | | | |
| Urease | -0.063 | 0.146 | 0.046 | -0.042 | 0.239 | -0.165 | 1 | | | | |
| DHA | 0.425 | 0.092 | 0.581 | 0.122 | -0.039 | -0.411 | 0.199 | 1 | | | |
| SMF | 0.326 | 0.014 | 0.172 | 0.066 | 0.166 | 0.11 | 0.001 | 0.193 | 1 | | |
| TF | 0.27 | -0.019 | 0.057 | -0.092 | 0.239 | -0.211 | -0.399 | 0.009 | -0.015 | 1 | |
| TA | 0.294 | -0.245 | -0.01 | -0.155 | -0.063 | -0.091 | -0.052 | -0.097 | -0.375 | 0.192 | 1 |

**BD-Bulk density, *Ca-Exchangeable calcium, *AN-Available nitrogen, *AS-Available sulphur, *Zn-DTPA extractable zinc, *Urease-Urease activity, DHA-Dehydrogenase activity, *TF-Total fungi, *TA-Total bacteria

**TABLE 4 (a)**

**Pearson correlation between soil quality indicators and yearly three times tomato growing soils**

| | pH | OC | AN | AP | AK | Ca | Mg | AS | Zn | Fe | Mn | B | BD | MWHC | VE | Urease | AAP1 | AAP2 | TA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 1 | | | | | | | | | | | | | | | | | | |
| OC | 0.405 | 1 | | | | | | | | | | | | | | | | | |
| AN | -0.107 | -0.203 | 1 | | | | | | | | | | | | | | | | |
| AP | -0.18 | -0.164 | 0.411 | 1 | | | | | | | | | | | | | | | |
| AK | 0.173 | -0.097 | 0.234 | 0.332 | 1 | | | | | | | | | | | | | | |
| Ca | 0.104 | 0.156 | -0.074 | 0.172 | 0.335 | 1 | | | | | | | | | | | | | |
| Mg | 0.151 | 0.269 | -0.22 | -0.187 | 0.156 | 0.672 | 1 | | | | | | | | | | | | |
| AS | 0.089 | 0.222 | 0.128 | 0.242 | 0.115 | 0.222 | 0.281 | 1 | | | | | | | | | | | |
| Zn | 0.077 | -0.003 | 0.295 | 0.641 | 0.161 | 0.337 | 0.107 | 0.289 | 1 | | | | | | | | | | |
| Fe | -0.113 | -0.22 | 0.515 | 0.075 | -0.172 | -0.187 | -0.045 | 0.062 | 0.179 | 1 | | | | | | | | | |
| Mn | -0.249 | -0.04 | 0 | 0.222 | 0.411 | 0.29 | -0.006 | 0.052 | 0.038 | -0.225 | 1 | | | | | | | | |
| B | 0.048 | 0.31 | 0.319 | 0.376 | 0.095 | 0.39 | 0.171 | 0.745 | 0.421 | 0.245 | 0.168 | 1 | | | | | | | |
| BD | -0.079 | 0.052 | 0.151 | 0.088 | -0.022 | 0.015 | 0.28 | 0.348 | 0.381 | 0.181 | -0.159 | 0.256 | 1 | | | | | | |
| MWHC | 0.061 | -0.168 | 0.396 | 0.122 | 0.334 | 0.182 | -0.192 | -0.19 | 0.032 | 0.145 | 0.263 | 0.019 | -0.522 | 1 | | | | | |
| VE | 0.195 | 0.21 | 0.32 | 0.337 | 0.58 | 0.1 | -0.285 | 0.087 | 0.207 | -0.018 | 0.227 | 0.237 | -0.211 | 0.523 | 1 | | | | |
| Urease | 0.162 | -0.191 | 0.464 | 0.344 | 0.449 | 0.047 | 0.016 | -0.039 | 0.191 | 0.208 | -0.137 | -0.036 | 0.123 | 0.055 | 0.2 | 1 | | | |
| AAP1 | -0.41 | -0.185 | 0.1 | -0.028 | 0.336 | 0.021 | -0.008 | -0.093 | -0.168 | -0.296 | 0.595 | -0.128 | 0.129 | -0.002 | 0.168 | 0.235 | 1 | | |
| AAP2 | 0.138 | -0.194 | 0.153 | 0.046 | 0.505 | 0.053 | -0.209 | -0.14 | -0.168 | -0.07 | 0.434 | -0.087 | -0.427 | 0.664 | 0.549 | -0.35 | 0.064 | 1 | |
| TA | 0.111 | 0.009 | 0.141 | 0.17 | 0.147 | 0.428 | 0.302 | 0.37 | 0.257 | 0.008 | -0.043 | 0.498 | 0.169 | -0.128 | -0.169 | 0.227 | -0.231 | -0.231 | 1 |

*EC- Electrical conductivity, *OC– Organic carbon, *AK– Available potassium, * Ca- Exchangeable calcium, *Mg- Exchangeable Magnesium, *AS-Available sulphur, *Zn-DTPA extractable zinc, *Cu-DTPA extractable copper, *Fe- DTPA extractable iron, * Mn-DTPA extractable manganese, *MWHC-Maximum water holding capacity, *VE-Volume of expansion, *AAP1-Acid phosphatase activity, *AAP2-Alkali phosphatase activity, *SMF-Soil micro-fauna, *TB-Total bacteria, *TF-Total fungi, *TA-Total actinomycetes correlated with VE (r = 0.652), AAP1 (r = 0.539) and AAP2 (R = 0.632). The VE of soil samples is significantly and positively correlated with DHA (r = 0.522) at a 5 per cent level of significance. Meanwhile, DHA is highly significant and positively correlated with bacteria (r = 0.408) and AAP1 is highly and positively significant with AAP2 (r = 0.797) at a 5 per cent level of significance similar finding was recorded by Pillai and Natarajan, 2004.

**Negative Correlation between Soil Properties in Yearly Two Times Tomato Growing Soils**

The data provided in Table 3 (b) illustrates a clear negative correlation between soil quality indicators in soils used for growing tomatoes twice a year. The correlation between AN and soil AS was highly significant and negative (r = 0.511). Similarly, pH showed a significant negative correlation with BD (r = 0.389). BD (r = 0.389) and Ca (r = 0.475) exhibited a highly significant negative correlation at a 5 per cent level of significance. Zn was highly significant and negatively correlated with DHA (r = 0.411). Urease and SMF were significantly negatively correlated with fungi (r = 0.309) and actinomycetes (r = 0.375) at a 5 per cent level of significance, respectively. Among all soil quality indicators, available nitrogen had the highest negative correlation with AS (r = 0.511) at a 5 per cent level of significance.

**Positive Correlation between Soil Properties in Yearly Three Times Tomato Growing Soils**

The correlation analysis between soil properties and soils used for growing tomatoes three times a year is presented in Table 4(a). The findings revealed a strong positive correlation between pH and OC (r = 0.405), AN and AP (r = 0.411), AN and Fe (r = 0.515), AN and MWHC (r = 0.396), AN and urease (r = 0.464), AP and Zn (r = 0.641), AP and B (r = .0.376), AK and Mn (r = 0.411), VE (r = 0.58) and urease (r = 0.449), Ca and Mg (r = 0.672), Ca and B (r = 0.39), Ca and actinomycetes (r = 0.428), AS and B (r = 0.745), AS and actinomycetes (r = 0.37), Zn and B (r = 0.421), Zn and BD (r = 0.381), Mn and AAP1 (r = 0.595), Mn and AAP2 (r = 0.434), B and actinomycetes (r = 0.498), MWHC and AAP2 (r = 0.664), MWHC and VE (r = 0.523) and VE and AAP2 (r = 0.549) at a significance level of 5 per cent. Notably, the highest positive correlation was observed between AS and B (r = 0.745), followed by MWHC and VE (r = 0.664).

**Table 4 (b)**

**Pearson correlation between soil properties in yearly three times tomato growing soils**

| | pH | Fe | BD | PS | MWHC | AAP1 | AAP2 | TF | SMF |
|---|---|---|---|---|---|---|---|---|---|
| pH | 1 | | | | | | | | |
| Fe | -0.113 | 1 | | | | | | | |
| BD | -0.079 | 0.181 | 1 | | | | | | |
| PS | -0.282 | 0.188 | 0.066 | 1 | | | | | |
| MWHC | 0.061 | 0.145 | -0.522 | -0.333 | 1 | | | | |
| AAP1 | -0.41 | -0.296 | 0.129 | -0.124 | 0.002 | 1 | | | |
| AAP2 | 0.138 | -0.07 | -0.427 | -0.171 | 0.664 | 0.342 | 1 | | |
| TF | 0.233 | -0.248 | -0.184 | -0.402 | 0.257 | 0.192 | 0.233 | 1 | |
| SMF | 0.111 | -0.378 | -0.198 | -0.349 | 0.306 | 0.064 | 0.236 | 0.262 | 1 |

*Fe-DTPA extractable iron. *BD-Bulk density. *PS-Pore space. *MWHC-Maximum water holding capacity, *AAP1-Acid phosphatase activity, *AAP2-Alkali phosphatase activity, *TF-Total fungi, *SMF-Soil microfauna

**Negative Correlation between Soil Properties in Yearly Three Times Tomato Growing Soils**

In yearly three times tomato growing soils, there is a negative correlation between various soil properties (Table 4b). The correlation coefficients indicate a significant and highly negative relationship between pH and AAP1 (r = 0.41), Fe and SMF (r = 0.378), BD and MWHC (r = 0.522), BD and AAP2 (0.427), pore space and fungi (r = 0.402) and pore space and SMF (r = 0.349) at a 5 per cent level of significance. Among these correlations, the highest negative correlation is observed between BD and MWHC (r = 0.522), followed by BD and AAP2 (r = 0.427).

The study found positive correlations between soil properties and 19 soil quality indicators, with exchangeable Mg and volume of expansion showing strong positive correlations. Other factors such as pH, electrical conductivity, organic carbon, exchangeable calcium, and micro-fauna also showed positive correlations. However, there was an inverse correlation between soil properties and tomato cultivation, with bulk density negatively affecting water holding capacity and expansion volume. Acid phosphates activities negatively impacted micro-fauna. The study also found a negative correlation between soil quality indicators in tomato-growing soils.

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