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Dioscorea, Cowpea, and Fenugreek: A Dietary Mineral Assessment.

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***Abstract*-- The study involves a range of tropical yam species (Dioscoreaceae) and two other crops, fenugreek and cowpea, grown on arid, nutrient-poor soils in Asia and Africa. Cowpeas have protein and fiber for dry areas, while fenugreek is tasty and medicinal. Fenugreek seeds lack endosperm; but they take up soil nitrogen, whereas cowpeas can take up nitrates. These seeds are high in iron, calcium, magnesium and potassium, all of which are beneficial to bone and immune health. Dioscorea tubers are rich in carbohydrates and bioactive compounds (diosgenin) that have health benefits. The mineral contents of *D. bulbifera*, *D. esculenta* and *D. alata* were determined precisely using nuclear absorption spectroscopy and the results showed that they are quite nutritious but there are interspecies variances. The preparation of community-safe meals requires consideration of what happens to these nutrients during cooking. Studies show that boiling cowpeas reduces nitrates and increases the availability of nitrogen, calcium, magnesium and potassium. The preparation of fenugreek differs and consequently food processing must be safe and healthful to ensure retention of nutrients. These yams and legumes are nutrition rich and the study recommends their regular usage. This needs more pharmacological studies to investigate the ethnomedicinal values of Dioscorea species for different diseases and strongly recommends the conservation of Dioscorea species with the reduction in their natural habitats.**

***Keywords*-- Nutrient uptake potential, *Vigna unguiculata*, *Trigonella foenum-graecum*, Mineral composition, Trace minerals, Sustainable agriculture**

I. INTRODUCTION

Nutrient-dense and resilient plant species are essential for sustainable agriculture and the preservation of food globally. Seeds and tubers have embryos and development nutrients and are vital to plant reproduction and survival of species. Experts in botany, agriculture and food science emphasize the need to learn the nutritional, medicinal and agronomic characteristics of some hardy crops, including legumes and tropical tubers to address issues of world malnutrition and sustainable agriculture.

Cowpea (*Vigna unguiculata*) and fenugreek (*Trigonella foenum-graecum*) are important crops in the family Fabaceae with complementary agronomic and commercial importance. Both are dicotyledonous and non-endospermic seeds and store their nutrients in the cotyledons for germination. They both fix nitrogen and help the health of the soil.

Cowpea is a drought tolerant pulse crop mostly planted in the tropical and subtropical areas of Africa and Asia, suitable for areas with limited soil and rainfall. Cowpeas are a staple food in cattle feed and anemia-fighting diets, rich in proteins, carbohydrates and minerals as iron. Fenugreek is a culinary spice and medicinal herb valued throughout South Asia, the Middle East and the Mediterranean. The essential oils, alkaloids and mucilage in the seeds help digestion, metabolism and blood sugar regulation and give calcium for building bones.

Alongside these essential legumes, the *Dioscoreaceae* family comprising roughly some species of tropical yams plays a critical role in global diets, particularly across the South Pacific, Africa, the Caribbean, and South America. Perennial herbs like *Dioscorea, Stenomeris, Tacca* and *Trichopus* yield fibre, vitamins, lipids and proteins. Dioscorea spp. are economically important to produce steroid saponins and bioactive compounds such as diosgenin with antioxidant and anti-inflammatory activities. These tubers are ethnomedicinally used to cure various ailments but require more pharmacological testing. The mineral contents of these two legumes and yams influence their nutritional and therapeutic values which are affected by the soil, environment and farming practices. Calcium, phosphorus, magnesium, potassium and trace elements such as zinc and copper are needed for metabolism, neuron function and the health of the immune system.

Hence, our study aims to appropriately quantify the mineralogy of these crucial crops. Atomic absorption spectroscopy will properly detect mineral levels in *Dioscorea bulbifera, D. esculenta*, *D. alata*, cowpea and fenugreek nutritional profiles. This research would help in validation of ethnomedicinal knowledge, promotion of nutrient rich species in human diet and help farmers to grow crops that promote human health and sustainable agriculture.

II. MATERIAL METHOD

Cowpea (*Vigna unguiculata*), *Trigonella foenum-graecum*, *Dioscorea bulbifera, D. esculenta, D. alata* were obtained for current investigation. The gathered sample were cleaned with water to remove surface contamination and then rinsed with distilled water. Prior to oven-drying, the samples were allowed to dry at room temperature.

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The dry ingredients were milled to a fine powder in a mortar and pestle and then formed into grits. The substance were acid digested and then sealed in a plastic container. Mineral examinations were carried out at Kasturi Agrotech Mineral Analysis Laboratory, Sangli.

III. Review Of Literature

Dioscoreaceae perennials, or yams, are diverse. They inhabit tropical and subtropical locations including Africa, Asia, and the Americas. More than 600 Dioscorea species have diverse forms and properties, making them significant in varied ecological environments (Bhattaccharjee, 2011). Environmentally, *Dioscorea* species are important. They shape their habitats. Vineyards and yam tubers minimize soil erosion, preserve soil integrity, and increase biodiversity (NGWE *et al.,* 2015). In many locations, these plants feed and house various groups. They also contribute to sustainable agriculture because they are grown in intercalary systems. Increased soil fertility and ecological interactions benefit different cultures using this farming method (Darkwa *et al.,* 2020).

Decomposing leaves and roots of *Dioscorea* species feed soil with nutrients. Culture techniques of Dioscorea species stress their potential to improve agricultural resistance to climate change. These plants can endure dryness and poor soil, making them suitable for cultivation in poor conditions. Yams may help secure food supply, especially in climate-vulnerable places (Nazir *et al.,* 2021). The preservation of Dioscorea culture and ecological equilibrium depend on sustainable agricultural methods like organic farming and agroforestry. *Dioscorea* species are important economically. These manufacturers' principal product is Ignonne, a staple food in many countries and vital to local diets. Yam farming boosts rural food security and employment (Do Nascimento *et al.,* 2021). Dioscorea species also produce diosgenin, a phytoestrogen used to make steroid hormones and medicines. Diosgenin extraction and treatment are lucrative sectors, adding to its economic importance (Azeteh *et al.,* 2019).In addition to economic benefits, Dioscorea species have health benefits. Their carbohydrate, vitamin, and mineral content make them essential to a balanced diet (Padhan & Panda, 2020). Yams provide energy and digestive wellness. Traditional medicine practices have identified Dioscorea species as effective in treating inflammation, diabetes, and reproductive health issues (Ojımelukwe *et al.,* 2021). Overall, *Dioscorea* species show how sustainable agriculture can suit local economic and health needs. The numerous species of *Dioscorea* play important roles in traditional medicine in various cultures due to their functions in ecosystems, agriculture, and medicine.

In African societies, notably opposing and winged. Dioscorea treats diarrhea, respiratory problems, and fever (Kumar *et al.,* 2017). Asian traditions use Dioscorea to cure exhaustion and hormonal abnormalities. Traditional *Dioscorea* use. It shows their value as food and cultural health ingredients.

The phytochemicals in hospitality species are responsible for their health benefits. Adomėnienė and Venskutonis (2022) found that steroid saponins, flavonoids, and polyphenols had anti-inflammatory, antioxidant, and immune-enhancing characteristics. Dioscorea saponins reduce cholesterol, suggesting they may benefit heart health. These traits support their traditional applications and allow for their incorporation in modern diets (Salehi *et al.,* 2019). Conservation and sustainable usage of Dioscorea species are difficult, despite their health and cultural benefits. Loss of habitat, review, and competition from planted crops endanger many species. South-East Asia's underutilized Dioscorea plants need urgent conservation (Ikiriza *et al.,* 2019). Dioscorea's traditional wisdom may also be lost when younger generations adopt modern lifestyles (Jahan *et al.,* 2019). Promoting sustainable agriculture is crucial to documenting and protecting this knowledge.

Progress in biotechnology offers discorean species cultivation and improvement. Tissue culture has been proven to boost yields and plant availability (Wang *et al.,* 2025). A simple food culture can become a superfood by using biotechnology to boost disease resistance and nutritional value. The metabolic pathways of Dioscorea offer a great chance for discovering new health-promoting chemicals (Chandrasekara and Josheph Kumar, 2016).

Cowpea and fenugreek are leguminous crops with important nutritional, health, and sustainable agricultural benefits. Black-eyed pea (cowpea) (*Vigna unguiculata*) has been a staple crop in Sub-Saharan Africa for generations. It thrives in arid and nutrient-deficient soils, making it suitable for sustainable agriculture (Jayathilake *et al.*, 2018). Cowpeas are rich in protein, fiber, vitamins, minerals, and iron and magnesium. Cowpea offers 22–25% protein and 5–6% dietary fiber, making it a good plant-based protein source, especially in places with little animal protein (Kaur *et al.*, 2018). A major legume used as a spice and medicine in Mediterranean, Middle Eastern, and Asian foods is fenugreek (*Trigonella foenum-graecum*). The seeds and leaves are eaten for nutrition and medicine. Fenugreek is rich in proteins, soluble fiber, iron, and magnesium. Olaiya and Soetan (2014) say fenugreek improves digestion and controls blood glucose. The seeds also include antioxidant and anti-inflammatory saponins, alkaloids, and flavonoids (Faisal *et al.*, 2024).

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Fenugreek and cowpea are essential to sustainable agriculture. Cowpea fixes nitrogen and improves soil health and production in crop rotation systems (Ishola & Aramide, 2022). Fenugreek improves soil structure and moisture retention (Legesse *et al.*, 2020). Additionally, these crops increase biodiversity and reduce synthetic fertilizer and pesticide use.

Sustainable techniques for *Dioscorea* and other traditional crops require biodiversity conservation and economic development. Local farmer support programs can ensure dioscorean sps health advantages and sustain varied cultivation practices. Communities can improve food safety, retain traditional knowledge, and benefit *Dioscorea* species for future generations by fostering conservation and economic development. Also cowpea and fenugreek are nutritious, sustainable, and profitable, according to research. Their high protein content, medicinal properties, and agricultural benefits make them vital to world food security and sustainable agriculture.

IV. Result And Discussion

Cowpea (*Vigna unguiculata*) and fenugreek (*Trigonella foenum-graecum*) seeds are nutritious. They are taken in many diets and have diverse mineral compositions that enhance health. This section compares the mineral composition of cowpea and fenugreek seeds to show how these differences affect food and agriculture. In current study, the nutritional attributes of two leguminous crops cowpea and fenugreek, are investigated under two distinct conditions (table 1): raw (control) and cooked while 3 different *Dioscorea* species directly compared with each other (table 2).

The current investigation shows comparative the nutritional value of two leguminous crops, *Vigna unguiculata* and *Trigonella foenum-graecum* alongwith *Dioscorea* species (*D. bulbifera, D. esculenta* and *D. alata)*. Nitrate, nitrogen, phosphorus, sodium, potassium, calcium, magnesium, sulfur, boron, zinc, iron, copper, manganese and molybdenum are measured. *Vigna unguiculata* and *Trigonella foenum-graecum* were tested fresh and cooked for their nutritional value. Nitrate, nitrogen, phosphorus, sodium, potassium, calcium, magnesium, sulfur, boron, zinc, iron, copper, manganese, molybdenum, ash, and moisture were assessed. Studies have demonstrated that cooking and other processing procedures considerably affect bean nutritional quality and mineral content (Deshpande, 1992; Mudryj *et al.*, 2014; Tharanathan & Mahadevamma, 2003).

Studies have demonstrated that cooking and other processing procedures considerably affect bean nutritional quality and mineral content (Deshpande, 1992; Mudryj *et al.*, 2014; Tharanathan & Mahadevamma, 2003). Cowpea nitrate level dropped from 44.90 PPM raw to 21.84 PPM cooked. This implies that cooking may significantly lower nitrate levels, which is healthy. In contrast, fenugreek had 146.03 PPM of initial nitrate, which dropped to 97.08 PPM after cooking. Fenugreek has more nitrate than cowpea, even if boiling lowers it. Cooking cowpea significantly reduced nitrate content. Thermal processing has been found to reduce nitrate and anti-nutritional components in many legumes (Kumar *et al.*, 2017; Sreerama *et al.*, 2012). Fenugreek also reduced nitrate levels after cooking, but it was still higher than cowpea.

Cooking cowpea boosted its nitrogen concentration from 2.74% to 3.58%, suggesting it may increase protein availability. Fenugreek's nitrogen concentration dropped from 4.59% to 4.08%, suggesting that boiling may change protein composition. Cooked cowpea has more nitrogen, indicating better protein availability. Mubarak (2005) and Khalil and Mansour (1995) found that boiling beans improves protein digestion. Fenugreek's nitrogen concentration decreased somewhat after boiling, probably due to protein denaturation or nutrient leaching (El-Adawy, 2002).

Fenugreek increased from 0.32% to 0.33% and cowpea from 0.22% to 0.27%, while both legumes had steady phosphorus amounts. Fenugreek dropped from 0.71% to 0.66% and cowpea from 0.69% to 0.68%, although sodium levels remained constant. Both legumes maintained phosphorus levels. Studies show that cooking affects phosphorus less than other minerals (Iqbal *et al.*, 2006). Boiling reduced sodium content somewhat, reflecting earlier observations that pulses affect sodium levels only modestly (Rao & Deosthale, 1982).

Cowpea's potassium concentration grew from 0.03% to 0.11% after boiling, while fenugreek's decreased from 0.13% to 0.09%. Boiling cowpeas may increase potassium availability, but not fenugreek. Cooked cowpea has higher potassium concentration than fenugreek, indicating species-specific responses to cooking (Hefnawy, 2011). During heating, cowpea's calcium increased from 0.14% to 0.25% and magnesium from 1.51% to 3.93%. Calcium declined from 0.26% to 0.23% in fenugreek, whereas magnesium increased from 3.43% to 3.83%. Due to better mineral extractability from plant tissues, cowpea boiling raised calcium and magnesium levels (Luo *et al.,* 2014).

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The sulfur content of both legumes increased after boiling, with cowpea rising from 2.93% to 3.76% and fenugreek from 3.94% to 4.07%. While fenugreek's boron content decreased from 9.67 PPM to 8.69 PPM post-cooking, cowpea's boron levels remained relatively unchanged. Sulfur content increased after cooking in both legumes. Sulfur content increased after cooking in both legumes.

Fenugreek's zinc level increased from 46.15 PPM to 58.26 PPM, but cowpea's reduced from 41.51 PPM to 34.24 PPM, suggesting that cooking may impact zinc bioavailability differently in both legumes. Heat processing raised zinc levels in fenugreek but decreased them in cowpea, suggesting that micronutrient availability can vary by species (Hemalatha *et al.*, 2007). The ferrous content of both legumes increased after boiling, with fenugreek from 880.95 PPM to 921.70 PPM and cowpea from 333.39 to 337.72 PPM, demonstrating that heating increases iron bioavailability. Iron concentration rose in both legumes after boiling, suggesting better iron availability (Hallberg & Hulthén, 2000; Hotz & Gibson, 2007).

Cowpea's copper level dropped from 49.95 to 23.56 PPM, whereas fenugreek's rose from 51.65 to 69.77. Previous nutritional studies indicated that cooking and boiling affected trace mineral availability and leaching in legumes, resulting in similar copper content changes (Hefnawy, 2011; Campos-Vega *et al.*, 2010).

Fenugreek's manganese levels rose from 131.72 to 142.65 PPM, whereas cowpea's fell from 23.34 to 21.71. species-specific mineral retention and cooking's effect on cellular structure and mineral extractability may explain this (Shimelis & Rakshit, 2005; Luo *et al.*, 2014). Cowpea's molybdenum content increased from 0.32 PPM to 0.56 PPM, while fenugreek's decreased from 0.61 PPM to 0.48 PPM, indicating that cooking conditions, mineral binding, and seed composition can affect legume trace mineral concentrations (Mudryj *et al.*, 2014).

The findings of the current investigation are shown nitrogen concentration in *D. esculenta* is 3.24%, which is higher than that of *D. bulbifera* and *D. alata*, which have nitrogen contents of 2.12% and 2.35%, respectively. Phosphorus is necessary for plant nourishment. It is essential to APM, ADP, ATP, and NADP. It helps plants transmit. It is evident from result that, *D. bulbifera* has 0.06% phosphorus, more than *D. esculenta* and *D. alata*, which have 0.04%. Plants need salt but use little. Na modulates plant cell osmotic pressure, increasing water use. Sometimes Na ions can substitute K ions in metabolic and osmoregulatory roles, allowing some interchangeability.

D. alata has 0.92% sodium, compared to 0.435% and 0.54% for *D. esculenta* and *D. bulbifera.* Potassium affects plant root growth [Jung *et al.* (2009)]. Potassium helps plant tissues transfer water, minerals, and carbohydrates. Potassium activates enzymes in plants, affecting ATP, glucose, and protein synthesis. Potassium boosts plant growth by boosting root formation and drought resistance. *D. alata* has 1.70% potassium, more than *D. bulbifera* (1.68%) and *D. esculenta* (1.43%). Calcium strengthens cell walls and membranes, protecting them against drought, pests, and dampness. It encourages root growth, which absorbs water and nutrients. The data indicate that *D. bulbifera* has 0.43% (43 mg/100g) more calcium than *D. esculenta* and *D. alata,* which have 0.23% and 0.24%, respectively.

Plants need 2% dry weight Mg, according to Epstein (1972). Vegetation needs magnesium. Chlorophyll nuclei contain this important component. All green plant needs it for photosynthesis. As an enzyme, it facilitates breathing. Also important for ribosomal particle aggregation. Low magnesium levels may cause leaf chlorosis. *D. bulbifera, D. esculenta,* and *D. alata* had similar magnesium contents of 2.52%, 2.92%, and 2.12%.

Plants need magnesium for many physiological and metabolic processes (M. Ishfaq 2022). Marschner (1986) claims that as a biotin enzyme component, it directly produces fatty acids. The IOM (2004) Food and Nutrition Board recommended 1.8 to 2.3 mg of manganese (Mn) daily. *D. bulbirera* (5.28 PPM) and *D. esculenta* (1.27 PPM) tubers have more manganese than D. alata (0.92 PPM). Plants vary in sulfur content, although it is low. This study found that *D. bulbifera* had 3.355% sulfur, compared to 1.87% and 2.06% for *D. esculenta* and *D. alata*. Many sulfur-containing chemicals help plants fight microbial infections (Hell 1997). Dioscreaceae species may control microbial illnesses. Plants with boron deficiency have reduced fertility, cell expansion, and meristematic death (Marschner, 1995). However, tiny amounts are necessary. Most crops need 20–100 ppm of boron in their foliage, although some crops have different needs (Plank, 1999). Plant hormone control requires it. *D. bulbifera, D. eaculenta,* and *D. alata* have Boron values of 15.39, 15.09, and 18.82 PPM, respectively, indicating no deficiency. Plants need zinc (Zn) for enzyme activation, metabolic and physiological activities, and ion homeostasis (Yang *et al.*, 2020; Alsafran, 2022). Stunted growth and leaf chlorosis result from zinc deficiency disrupting plant metabolism. Insufficient nutritional absorption can lead to zinc deficiency in the diet (Li *et al.*, 2013). Zinc's role in activating and stabilizing metalloenzymes affects plant-pathogen interactions (Fones and Preston, 2012).

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The results indicate that *D. esculenta* [24.34 PPM] is more resistant to infections than *D. bulbifera* [21.66 PPM] and *D. alata* [18.53 PPM].

Iron is involved in chlorophyll precursor synthesis, according to Machold and Stephan (1969). Iron storage phytoferritin in the chloroplast stroma holds 5,000 Fe 3+ atoms. According to Marschner (1986). Iron is essential for DNA synthesis, respiration, and photosynthesis, which most living things need. Oxidized ferric iron is the third most limiting nutrient for plant development and metabolism because it is poorly soluble in aerobic conditions. For many crop plants, iron deficiency decreases nutritional quality and yields. *D. esculenta* has 63.98 PPM ferrous, compared to 50.79 and 47.12 PPM for *D. bulbifera* and *D. alata.*

Copper (Cu), a trace element, is essential for plant growth. It acts as a cofactor for various enzymes and is involved in protein transport, cell wall metabolism, respiration/photosynthesis electron transfer, and hormone signal transduction [Guang Chen *et al.*, 2022]. It and another photosynthesis-related trace element are essential for reproductive development. It is linked to photosynthetic redox enzymes (Haehnel, 1984). According to the statistics, *D. alata* (7.36 PPM) has more copper than *D. bulbifera* (6.99 PPM) and *D. esculenta* (2.70 PPM).

Plants need magnesium for several physiological and metabolic processes [M. Ishfaq 2022]. Marschner (1986) claims that as a biotin enzyme component, it directly produces fatty acids. The IOM (2004) Food and Nutrition Board recommended 1.8 to 2.3 mg of manganese (Mn) daily. *D. bulbirera* (5.28 PPM) and *D. esculenta* (1.27 PPM) tubers have more manganese than *D. alata* (0.92 PPM).

Hydroponic tomato research by Arnon and Stout (1939) showed the role of molybdenum in plant growth. Molybdenum may protect dental enamel. (1971) Curzon and friends. Two enzymes convert nitrate into nitrite, a dangerous nitrogen form, and ammonia, which requires molybdenum. Plants synthesize amino acids with ammonia. Thus, legume symbiotic nitrogen-fixing microbes must absorb ambient nitrogen. Plants need molybdenum to transform inorganic phosphorus into organic forms. The current study shows *D. bulbifera, D. esculenta,* and *D. alata* concentrations of 0.28, 0.46, and 0.32 ppm.

V. Conclusion

The study confirms that boiling various legumes changes the minerals contained. Cooking cowpea reduced the levels of nitrates more than fenugreek. This could make the food safer and healthier." Changes in nitrogen levels point to heating increasing protein in cowpeas and decreasing it in fenugreek.

Calcium, magnesium and potassium become more extractable and less leachable or less incorporated in seed structure after heat treatment. The levels of zinc, copper, manganese and molybdenum in the two beans vary. Research shows that the nutritional value and mineral absorption of cowpeas and fenugreek are significantly affected by the cooking process. Depending on the seed type and processing type boiling can increase the levels of iron and some other elements but decrease the levels of others. So it's important to properly prepare these beans, so that we may obtain the most nutritional benefits. The study highlights the importance of cowpea and fenugreek in a balanced diet and supports their utilization in food systems and sustainable agriculture. The results also suggests that the *Dioscorea* species has a good mineral presence. The results of this study suggest that *Dioscorea* species are an effective mineral-rich dietary supplement.

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Table 1. Comparative analysis of mineral content in cowpea and fenugreek.

	Sample No.	***Vigna unguiculata* (Cowpea)**		***Trigonella foenum-graecum* (Fenugreek)**	
Sr. No.	SAMPLE TYPE	CONTROL (NORMAL)	COOKED	CONTROL (NORMAL)	COOKED
	Parameter	Average	Average	Average	Average
1	**Nitrate (PPM)**	44.90	21.84	146.03	97.08
2	**Nitrogen (%)**	2.74	3.58	4.59	4.08
3	**Phosphorus (%)**	0.22	0.27	0.32	0.33
4	**Sodium (%)**	0.69	0.68	0.71	0.66
5	**Potassium (%)**	0.03	0.11	0.13	0.09
6	**Calcium (%)**	0.14	0.25	0.26	0.23
7	**Magnesium (%)**	1.51	3.93	3.43	3.83
8	**Sulphur (%)**	2.93	3.76	3.94	4.07
9	**Boron (PPM)**	9.20	9.12	9.67	8.69
10	**Zinc (PPM)**	41.51	34.24	46.15	58.26
11	**Ferrous (PPM)**	333.39	337.72	880.95	921.70
12	**Copper (PPM)**	49.95	23.56	51.65	69.77
13	**Manganese (PPM)**	23.34	21.71	131.72	142.65
14	**Molybdenum (PPM)**	0.32	0.56	0.61	0.48

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Table 2. Mineral uptake potential in *D. bulbifera, D. esculenta, and D. alata*.

Sr. No.	Parameter	*D. bulbifera*	*D. esculenta*	*D. alata*
1	Nitrate (PPM)	70.38	19.82	58.65
2	Nitrogen (%)	2.12	3.24	2.35
3	Phosphorus (%)	0.06	0.04	0.03
4	Sodium (%)	0.54	0.43	0.92
5	Potassium (%)	1.68	1.43	1.70
6	Calcium (%)	0.43	0.23	0.24
7	Magnesium (%)	2.52	2.92	2.12
8	Sulphur (%)	3.35	1.87	2.06
9	Boron (PPM)	15.39	15.09	18.82
10	Zinc (PPM)	21.66	24.34	18.53
11	Ferrous (PPM)	50.79	63.98	47.12
12	Copper (PPM)	6.99	2.70	7.36
13	Manganese (PPM)	5.28	1.27	0.92
14	Molybdenum (PPM)	0.28	0.46	0.32