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MICRONUTRIENT-IMPROVED LIQUID NPK FERTILIZER EFFECT ON GROWTH OF OUR LOCAL CROPS

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Abstract

This study investigates the effects of liquid NPK fertilizer and micronutrient-improved NPK with specific gravity and pH of the stock solution that decreases with dilution was found to be 1.44 and 5.6 (NPK), and 1.65 and 5.4 (micronutrient-improved NPK) respectively on yield and quality of tomato, curry plant, black beans, and fluted pumpkin. The fertilizers were applied at varying concentrations (0-1.0%) twice a week for two months. The study found that Liquid NPK fertilizer increased crop yields by 49.55-52.80% while Micronutrient-improved NPK liquid fertilizer boosted yields by 55.56-69.47% (dried weight). At optimal concentration (0.5%), micronutrient-improved NPK outperformed liquid NPK by 5.63-16.65%. These findings suggest that applying liquid NPK and micronutrient-improved NPK fertilizers can significantly enhance crop yields, quality, and improving national food security when used effectively.

Introduction

To overcome the challenge of poor yield and maximize crop production that will meet the requirements of modern-day farming, organic and/or inorganic plant nutrient are seriously considered to boost yield and quality to reduce food shortage (Uchida, 2000; Jaja and Barber, 2017; Angus, 2012; Kai and Adhikari, 2021; Khanom et al., 2013). To compensate for what the soil is lacking and/or balance the macronutrients and micronutrients to enhance better development, optimal yield and improved quality of crops (Silver et al., 2021; Javed et al., 2022; Stewart, 2023; Sangina and Woomer, 2009; Neina, 2019; Msimbira & Smith, 2020 (Toor et al., 2021; Zewide, &

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Sherefu, 2021; Coleto et al., 2023; Ronen, 2007; Çalişkan & Çalişkan, 2018, Jiaying et al., 2022; White & Brown, 2010).

There are many factors guide the choice of fertilizer comprises what the soil in question is lacking, application method, cost, and storage method (FAO, 2017; Penuelas et al., 2023; Stewart et al., 2005). Liquid fertilizers allow for fast acting of crops through better absorption into the roots and/or leaves of plants making available the needed nutrient that will affect for a better yield for a wide range of plants than granular fertilizers that roots avert due to the excess nitrogen and potassium in them. (Isleib, 2016; Martínez-Alcántara et al., 2016; Bogusz et al., 2021; Šarauskis et al., 2020; Sabry, 2015; Bouranis et al., 2018).

Several studies revealed that among the mineral elements plant required, three are needed in large quantity (macronutrient) while 14 other elements are required in small quantities (micronutrient) and they all play a crucial role in proper development and boost yield. Among these mineral elements carbon, hydrogen, and oxygen are also considered part of the proximate composition plants (Stewart, 2023; Silva & Uchida, 2000; Kathpalia & Bhatla, 2018; White & Brown, 2010).

The lead enzyme reactions involving nitrogen processes in plants are catalyzed by molybdenum (as molybdate ion) which control all material that decelerate nitrogen uptake (Bittner, 2014; Rana et al., 2020; Oliveira et al., 2022; Tokasheva et al., 2021). Antioxidant defense activities against drought stress that strengthen plant wellness and yield, are fostered by molybdenum (Abou Seeda et al., 2020). The absence or deficiency of molybdenum in the land may lead to retarded growth and development where pale green to yellowish green leaves signaling poor growth and the leaves appear pale green or yellowish green in colour due to nitrogen deficiency. On the other hand, excess of molybdenum result to purple leaves or yellow in legumes (Kaiser et al., 2005).

Zinc, a trace metal (20 to 100 ppm in a plant) absorbed as Zn^{2+} ions from the soil hold a considerable role in plant cultivation, development and yield (Yang et al., 2020; Alsafran et al., 2022; Noulas et al., 2018; Saleem et al., 2022; Suganya et al 2020; Kambe et al., 2015). When it is not sufficient in the soil it retards growth, development and many other metabolic reactions in the plant that will result in poor yield (Sharma et al., 2012; Slaton et al., 2005). When inadequate in the soil the plant leaves will turn to yellow, development, and yield will be retarded (Saleem et al., 2022). The inadequacy can be remedied by dosing the site with either solid or water solution of zinc sulphate, zinc oxide, zinc carbonate, zinc nitrate, and zinc chloride directly to the soil fix the inadequacy (Noulas et al., 2018; Saleem et al., 2022; Subbaiah et al., 2016).

Copper is one of the essential trace metal nutrients absorbed as cupric (Cu^{2+}) ions that is greatly utilized in key enzymatic plant activities such as chlorophyll and photosynthesis, seed production, and in synthesis of carbohydrates and protein (Abou Seeda et al., 2020; Aguirre, & Pilon, 2016; Gautam et al., 2015). When not sufficient (as low as 5 ppm) the leaves will start darkening with fading shades (Yruela, 2005; Kumar et al., 2020; Laporte et al., 2020), but when in excess the crop will experience unfavorably development and environment degradation, that will negatively affect yield (Gautam et al., 2015; Chen et al., 2022; Kumar et al., 2020; Alengebawy et al., 2021; Arif et al., 2016; José Rodrigues Cruz et al., 2022; Madejón et al., 2009; Fidalgo et al., 2013). The incorporation of copper sulfate into NPK, sprayed on the crop will not only fertilize the crop but also act as fungicide for optimal yield and control of diseases (Tamm et al., 2022; Torre et al., 2018).

For optimum plant development, growth and yield manganese (Mn) is needed for sound metabolism (Alejandro et al., 2020; Millaleo et al., 2010; Schmidt & Husted, 2019; Andresen et al., 2018; Wang et al., 2022; Avila et al., 2013). Browning of leaves with a fading shady background is as a result of insufficiency and will retard growth, normal development, and thereby reduce yield (Jannah et al., 2022; Mousavi et al., 2011; Zewide & Sherefu, 2021. But when above the normal range of 20 to 300 ppm will masque the bioavailability of nutrients (nitrogen, phosphorus, calcium, magnesium, and iron) and hence reduce proper development and yield through the yellowing and browning of leaves (Brouder et al., 2003; Ceballos-Laita et al., 2018 & 2020; Li et al., 2019; Alejandro et al., 2020; Millaleo et al., 2010; Fernando & Lynch, 2015). The insufficiency can be compensated by dosing the crop with either solid or aqueous solution of manganese sulfates, chloride, or oxides, or chelated forms such as manganese ethylenediamine tetraacetate, manganese diethylene pentaacetic acid, or Mn-lignosulfonate (Hawson, 2016; Brouder et al., 2003).

Material and methods

Ridge preparation

Sixty-three flat-topped ridges of 6 to 8 inches tall of 3 ft by 6 ft after cultivation were cultivated in front of biological garden of Department of applied Biology and Biotechnology and each crop planted in three ridges (control and treated) for each fertilizer concentration.

Crop samples

The crop samples seedling is tomato (*Solanum lycopersicum*), curry plant (*Murraya koenigii*), black beans (*Vigna unguiculata*) and fluted pumpkin (ugu) (*Telfairia occidetalis*) were bought from Market Garden, Enugu State Ministry Agriculture on April 17^{th}, 2024.

Planting of sample seedlings

The sample seedling was planted in three adjacent ridges and labelled with a wooden sign post as control (without liquid fertilizer application) and treated (with liquid NPK fertilizer and micronutrient improved NPK fertilizer). The sample seedlings germinated 7-14 days after planting and liquid fertilizer applied for two months after germinating.

NPK liquid fertilizer formulation

The NPK fertilizer (4:3:8) was formulated by dissolving carefully weighed urea (0.7g), potassium nitrate (0.27 g), ammonium ferrous sulphate 0.32 g, and sodium phosphate (0.32 g) in de-ionized water and the volume made up to one liter. This ratio is 4 % nitrogen, 3 % phosphorous, and 8 % potassium.

Micronutrient-improved liquid NPK fertilizer formulation

Among the main micronutrients (boron, manganese, molybdenum, copper, zinc, and iron) (Igor, 2023), boron as boron oxide (0.1 g), manganese as manganese oxide (0.01 g), molybdenum as ammonium molybdate (0.01 g), copper as copper sulphate (0.01 g), zinc as zinc oxide (0.01 g) was incorporated to NPK (3:4:8) were carefully weighed and dissolved in NPK liquid fertilizer solution and the volume made up to one liter.

Specific gravity determination

The specific gravity bottle method was employed and the weight difference between an empty and filled bottle with liquid NPK fertilizer and dividing by weight of an equal volume of water to find the specific gravity of the liquid fertilizer.

PH determination

The electrode of the pH meter was first calibrated with acetic acid-sodium acetate buffer 4, 6.3, and 7.3. The electrode was washed by immersing in a beaker of distilled water and then immersed into the fertilizer sample solution until a steady reading is reached.

Fertilizer application

The stock fertilizer solution was diluted by making up 0:200, 0.2:200, 0.5:200,1:200, 0.75:200, 2:200 V/V to 20 liters with water to obtain 0, 0.1. 0.25, 0.5, 0.75 and 1.0 %. The germinated seedlings were sprayed with 20 L of water twice a week for two months and labelled with a wooden sign post as control (without liquid fertilizer application) while the ridges watered with 20 L of each concentration (0, 0.1. 0.25, 0.5, 0.75 and 1.0 %) of diluted fertilizer solution (as treated with liquid fertilizer).

Results and discussion

Applying each concentration of liquid NPK fertilizer and liquid micronutrient improved NPK fertilizer have a very significant effect when compared with the control

The specific gravities of the stock solution of the formulated liquid NPK fertilizer and micronutrient improved NPK liquid fertilizer were found to be 1.44 and 1.65 respectively. It was observed that the specific gravity of concentrations increases with increase in concentration from the control (0 %) concentration. However, the specific gravity of both the formulated liquid NPK fertilizer and micronutrient improved NPK liquid fertilizer were found to increase with increase in concentration (Table 1). Dilution often affect the physical and chemical properties of the solution as it is observed with the specific gravity and pH of the diluted formulated liquid NPK fertilizer and micronutrient improved NPK liquid fertilizer respectively (Physics Forums, 2019).

The pH of the stock liquid NPK fertilizer and micronutrient improved NPK liquid fertilizer solution was determined to be 5.6 and 5.4 respectively, and the acidic pH decreases as the dilution increases. The pH of the dilutions 0, 0.1, 0.25, 0.5, 0.75 and 1.0 % was observed to decrease from 7.1 to 6.4. The pH of the diluted concentrations was found to agree with literature recommendation that the optimal pH range for plants is usually between 5.5-7.5. Below 5.5 is considered an acidic pH and above 7.5 is considered alkaline (Sensorex, 2021).

Table 1: The pH **and Specific gravity of various concentration of the formulated liquid NPK fertilizer and micronutrient improved NPK fertilizer.**

Fertilizer concentration (%)	**Liquid NPK fertilizer**		**Liquid micronutrient improved NPK fertilizer**	
	pH	**Specific gravity**	pH	**Specific gravity**
0 (Control)	7.1	1.00	7.1	1.00
0.1	7.5	1.09	7.3	1.11
0.25	6.9	1.16	7.1	1.22
0.5	6.6	1.20	6.8	1.26
0.75	6.3	1.27	6.6	1.30
1.0	5.9	1.31	6.4	1.36

In the triplicate moisture content of 100 g leaves determination, the treated samples were found to contain more moisture than the control (untreated) and that the moisture content of the treated samples increases with increase in concentration of the formulated liquid NPK fertilizer and micronutrient improved liquid NPK fertilizer. Probably this may be due to the fact that fertilizers retain moisture in the in the lower soil and thereby make the nutrient more soluble and available for the crops (Mamutov et al., 2021).

Table 2: Percent moisture content for various concentration of the formulated liquid NPK fertilizer and micronutrient improved NPK liquid fertilizer per 100 g leaves.

Fertilizer	Sample seedlings			
concentration (%) Liquid NPK fertilizer	Tomato	Curry leaf	Black beans	Fluted pumpkin
0	75.0 ± 0.18	39.6 ± 0.17	67.2 ± 0.09	70.2 ± 0.07
0.1	77.7 ± 0.07	77.5 ± 0.12	69.1 ± 0.17	73.3 ± 0.13
0.25	80.4 ± 0.14	79.6 ± 0.13	72.4 ± 0.15	76.1 ± 0.12
0.5	82.2 ± 0.19	84.8 ± 0.08	78.0 ± 0.11	81.0 ± 0.11

0.75	83.8 ± 0.09	88,9 ± 0.15	79.3 ± 0.14	82.9 ± 0.06
1.0	84.0 ± 0.13	90.3 ± 0.10	79.7 ± 0.05	83.3 ± 0.04
Micronutrient improved NPK Liquid fertilizer				
0.1	79.9 ± 0.15	79.7 ± 0.14	70.7 ± 0.09	73.3 ± 0.20
0.25	82.7 ± 0.11	80.2 ± 0.09	72.9 ± 0.12	76.8 ± 0.02
0.5	83.8 ± 0.14	83.9 ± 0.14	75.3 ± 0.11	81.3 ± 0.10
0.75	84.1 ± 0.17	85,7 ± 0.04	76.6 ± 0.06	84.1 ± 0.05
1.0	84.6 ± 0.31	88.5 ± 0.11	77.4 ± 0.03	84.9 ± 0.10

It is interesting to note that the untreated curry leaves were found to contain less moisture (39.6 ± 0.27 %) than black beans (67.2 ± 0.09 %), fluted pumpkin (70.2 ± 0.07 %) and tomato (75.0 ± 0.28 %) leaves. However, the moisture content of the treated with 0.1, 0.25, 0.5, 0.75 and 1.0 % of the formulated liquid NPK fertilizer and micronutrient improved liquid NPK fertilizer show more moisture content more than the untreated (control) and the moisture content increases with increase in concentration. Moreso, the moisture content of the treated with the formulated liquid NPK fertilizer and micronutrient improved liquid NPK fertilizer did not show any significant difference among the same concentration for all the concentrations (Table 2). It is fascinating to note that the formulated liquid NPK fertilizer and micronutrient improved liquid NPK fertilizer contain nearly the same moisture content. The percent moisture content of crop leaves was observed to decreases with increase in concentration of the liquid NPK fertilizer and micronutrient improved liquid NPK fertilizer and was optimal at 0.5 % concentration for all the crops. The wet weight probably varies because of the physiological and environmental condition of the plant species and how long it took before the determination.

The lesser moisture content shows that the leaves are less prone to bacteria attack and will preserve more than those with higher moisture content (Amit et al., 2017; van 't Hag et al., 2020; Liu et al., 2022; Mediani et al., 2022; Saha, 2020; Nielsen, 2010). This means that the untreated (control) will preserve more than the treated and the treated need more preservation than the untreated probably by dehydration.

Table 3: **The effect of liquid NPK fertilizer concentration on the wet and dry weight of sample leaves.**

Fertilizer conc.	**Sample**							
	Tomato		**Curry leaf**		**Black beans**		**Fluted pumpkin**	
	Wet weight (g)	**Dry weight (g)**	**Wet weight (g)**	**Dry weight (g)**	**Wet weight (g)**	**Dry weight (g)**	**Wet weight (g)**	**Dry weight (g)**
0	82.00 ± 0.01	41.11 ± 0.04	63.80 ± 0.01	17.65 ± 0.07	34.50 ± 0.07	28.30 ± 0.02	19.67 ± 0.09	15.91 ± 0.07
0.1	97.30 ± 0.07	57.33 ± 0.02	73.03 ± 0.07	19.96 ± 0.03	36.44 ± 0.02	23.29 ± 0.03	31.48 ± 0.05	16.74 ± 0.03
0.25	103.11± 0.04	67.32 ± 0.03	81.74 ± 0.05	22.54± 0.02	47.33 ± 0.03	39.78 ± 0.06	43.09 ± 0.02	22.41 ± 0.09
0.5	120.42 ± 0.09	82.14 ± 0.01	96.40 ± 0.03	35.91 ± 0.01	51.87 ± 0.01	56.09 ± 0.07	61.47 ± 0.07	33.71 ± 0.01

0.75	122.41 ± 0.03	83.13 ± 0.05	101.34 ± 0.04	36.55 ± 0.09	52.07 ± 0.08	56.73 ± 0.04	61.99± 0.01	34.76 ± 0.02
1.0	130.54 ± 0.02	85.45 ± 0.09	112.18 ± 0.03	37.92 ± 0.05	52.24 ± 0.09	57.08 ± 0.08	62.17 ± 0.01	35.24 ± 0.05

The micronutrient improved NPK liquid fertilizer were observed to significantly improve the wet and dry weight of the plants than the untreated (control) and the wet and dry weight are found to increase with increase in concentration of the formulated fertilizer. It was also observed that the yield (wet and dry weight) was optimal with 0.5 % concentration of formulated liquid NPK fertilizer and micronutrient improved NPK liquid fertilizer respectively. This probably may be for the fact that the leaves absorb the fertilizers directly and increase the soil water content with the nutrient in them thereby making available the soil nutrient and that of the formulated fertilizers hence stimulate plant growth (yield) (Gill, 2022; Chtouki et al., 2022; Subbani et al., 2012; Jiang et al., 2024; Zhang et al., 2021; Yuan-meng et al., 2021). It can be said that formulated liquid NPK fertilizer and micronutrient improved NPK liquid fertilizer significantly affected growth (yields) of the crops studied (both wet and dried weight) and optimal at the 0.5 % concentration.

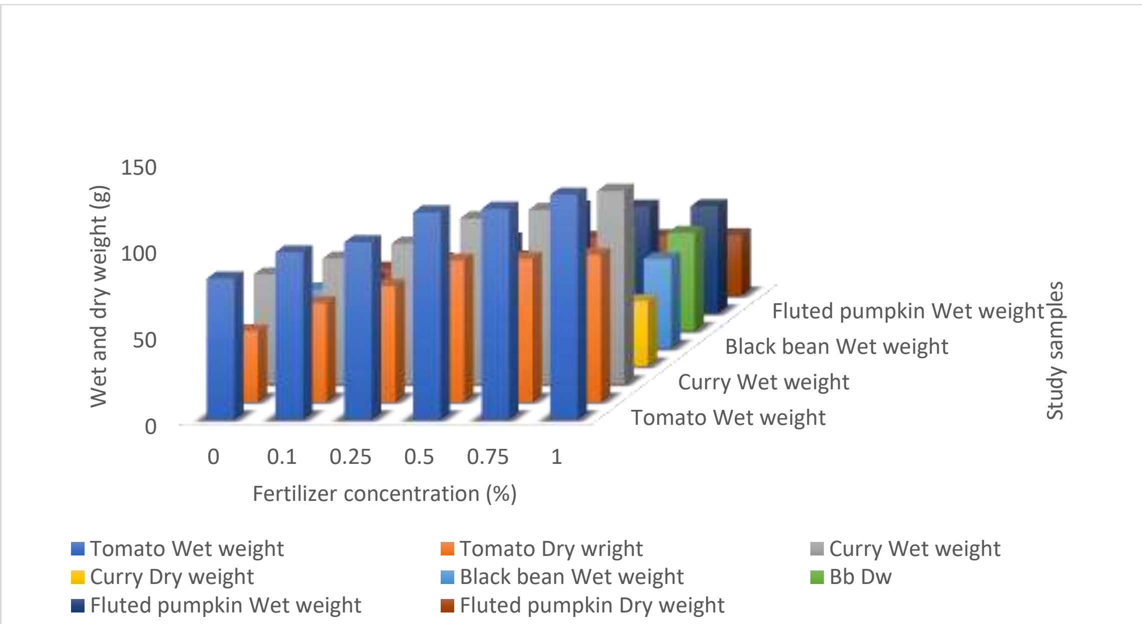

Figure 1: The effect of liquid NPK fertilizer concentration on the wet and dry weight of sample leaves.

Growth (yield) is a measure of wet and dry weight of the crop (biomass) some micronutrients Zn, Fe and Cu are required (Owusu-Sekyere, 2021). For optimal yield zinc is needed because it supports in the making of proteins and DNA, which is a measure of proper development and growth of a plant. Copper is a component of chlorophyll that plays an essential role in photosynthesis and making of vitamin A, which if not sufficient will hamper protein production. Copper acts as a catalyst in enzymes reaction charge with lignin production (Kaiser & Rosen, 2023; Bloodnick, Ed. 2014; Chen et al., 2022). The presence of copper in the liquid micronutrient improved NPK may be responsible for the appreciably increase in both wet and dry weight of the crops because of the enhanced chlorophyll, photosynthesis, protein, and lignin production.

Table 2: **The effect of micronutrient-improved liquid NPK fertilizer concentration on the wet and dry weight of sample leaves.**

FC	Sample			
	Tomato	Curry leaf	Black beans	Fluted pumpkin

	Wet weight (g)	Dry weight (g)	Wet weight (g)	Dry weight (g)	Wet weight (g)	Dry weight (g)	Wet weight (g)	Dry weight (g)
0	82.00 ± 0.01	41.11 ± 0.04	63.80 ± 0.01	17.65 ± 0.07	34.50 ± 0.07	28.30 ± 0.02	19.67 ± 0.09	15.91 ± 0.07
0.1	100.01 ± 0.03	61.27 ± 0.13	74.03 ± 0.10	20.05 ± 0.07	55.13 ± 0.11	35.55 ± 0.07	33.81 ± 0.04	17.28 ± 0.03
0.25	111.53 ± 0.12	66.19 ± 0.11	89.74 ± 0.16	33.94 ± 0.09	69.41 ± 0.04	41.78 ± 0.12	44.93 ± 0.07	21.44 ± 0.09
0.5	139.29 ± 0.01	92.51 ± 0.14	116.03 ± 0.13	44.66 ± 0.12	104.39 ± 0.08	72.98 ± 0.06	77.28 ± 0.12	52.11 ± 0.02
0.75	143.45 ± 0.05	93.32 ± 0.12	118.34 ± 0.09	45.93 ± 0.13	106.17 ± 0.07	73.41 ± 0.04	77. 96 ± 0.02	53.06 ± 0.01
1.0	144.62 ± 0.01	95.44 ± 0.08	119.18 ± 0.12	46.02 ± 0.18	106.92 ± 0.11	73.94 ± 0.09	78.11 ± 0.03	53.39 ± 0.05

Key: FC → Fertilizer concentration

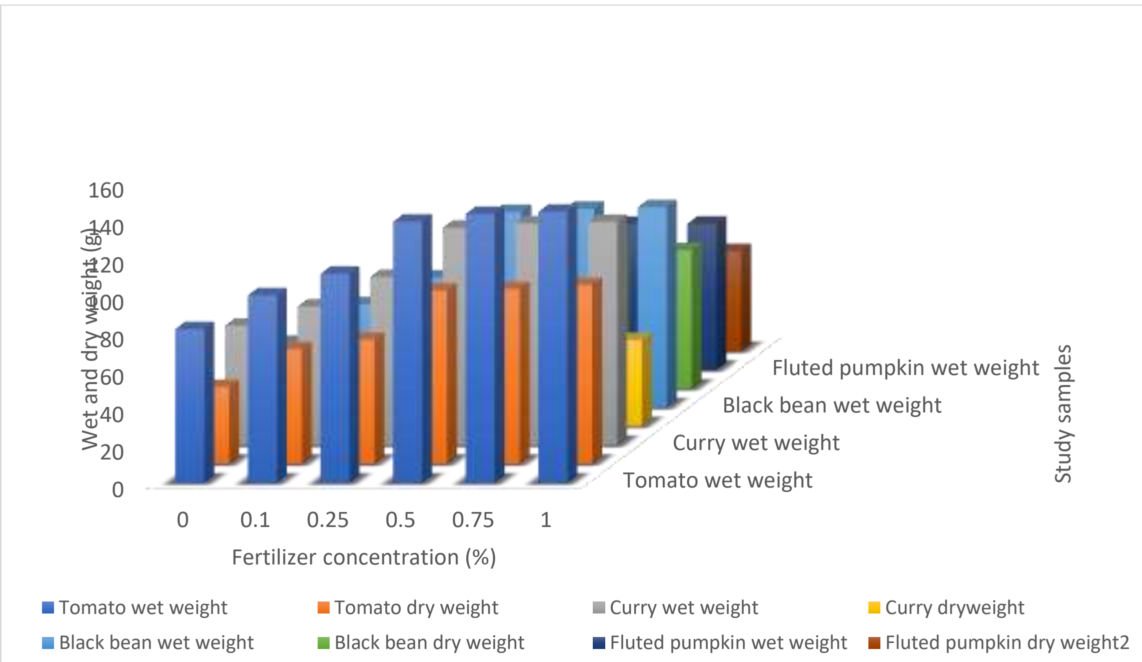

Figure 2: Comparative effect of liquid NPK and liquid micronutrient improved NPK fertilizers concentration on the dry weight of sample leaves.

The liquid NPK fertilizer increased true yield (dry weight) by nearly double above (49.55 – 52.80 %) that of the control (untreated or 0 % fertilizer), while micronutrient improved NPK liquid fertilizers gave true yield (dry weight) that is significantly above 50 % of the control (untreated or 0 % fertilizer) (tomato 55.56 %, curry 60.48 %, black beans 61.22 %, and fruited pumpkin 69.47 %) respectively. The result clearly showed that the dry weight (true yield) of sample leaves revealed that the yield of liquid micronutrient improved NPK liquid fertilizers is greater by about 5.63-16.65 % than liquid NPK fertilizer at the optimum concentration of 0.5 % (Fig. 3).

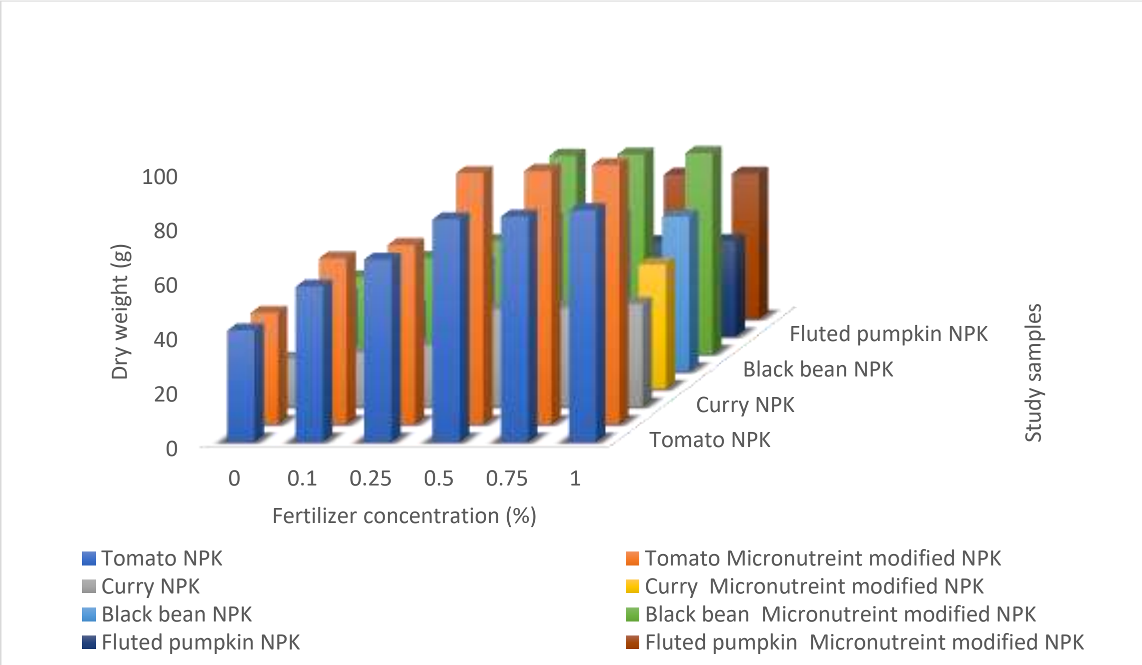

Figure 3: Comparative effect on true yield **of liquid NPK and liquid micronutrient improved NPK fertilizers concentration of sample leaves.**

The liquid NPK and micronutrient improved NPK liquid fertilizer was found to positively affect yield for the four study samples but most effectively with fluted pumpkin leaves found to have the highest yield (most positively affected) (52.80 % and 69.47 %) respectively.

Conclusion

The liquid NPK fertilizer increased true yield (dry weight) by nearly double (49.55 – 52.80 %) that of the control (untreated or 0 % fertilizer), while micronutrient improved NPK liquid fertilizers gave true yield (dry weight) that is significantly above 50 % of the control (untreated or 0 % fertilizer) (55.56 – 69.47 %) respectively. The result of the dry weight (true yield) of sample leaves revealed that micronutrient improved NPK liquid fertilizers improved yield by about 5.63-16.65 % than liquid NPK fertilizer at the optimum concentration of 0.5 %. This study demonstrated that applying liquid NPK and micronutrient-improved NPK fertilizers can significantly enhance crop yields, quality, and improving national food security when use effectively.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

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