



THE EFFECT OF COMBINED APPLICATION OF ORGANIC UREA AND FARM YARD MANURE ON THE PERFORMANCE OF SPINACH AND NITRATE CONTENT IN THE NORTHERN GUINEA SAVANNA.

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ABSTRACT

Type of fertilizer is considered for influencing spinach yield and level of nitrate concentration for normal crop consumption. This experiment investigates plant growth, yield and nitrate content of spinach with different fertilizer types and levels. In a two location field experiment three rates of farm yard organic manure (6, 8 and 10 t ha⁻¹ of FYM) and three levels of N.P.K fertilizers (100:30:30, 150:30:30 and 200:30:30) were used and three combination of the two kinds of fertilizers (3t ha⁻¹ FYM + 90 kg N ha⁻¹, 4t ha⁻¹ FYM + 70 kg N ha⁻¹, and 5t ha⁻¹ FYM + 50 kg N ha⁻¹) including control (without any fertilizer) were laid out in a Randomized Complete Block Design and replicated thrice. The result showed that spinach treatment with urea fertilizer was superior to the treatment with farm yard manure and the control but comparable to treatment with combined application of the urea and farm yard manure. The highest and significant relative yield of 39587.92 kg ha⁻¹, 40222.0 kg ha⁻¹ and 36895.21 kg ha⁻¹ 36354.5 kg ha⁻¹ were obtained from urea treatments and combined application of urea and farm yard manure at Samaru (DAC) and Shika (IAR) respectively. While the highest farm yard manure treatments of 28792.84 kg⁻¹ and 27304.55 kg⁻¹ were produced at Samaru and Shika respectively. However, the yield kg ha⁻¹ obtained with farm yard manure in both locations were higher but not significantly different from that of the control. Nitrate concentration in the fully developed leaves samples of spinach were monitored at 4, 6 and 8 weeks after planting. Nitrate accumulation in urea fertilized plots was observed to be directly linked to increase in nutrient concentration. Even then the highest nitrate accumulation (1627 mg kg⁻¹ and 1675 mg kg⁻¹) which was by urea treated plants at Samaru and Shika respectively, which was a function of growth was about 55.52 – 62.54 % and 38.89 – 47.73 % higher than nitrate concentration 1001 mg kg⁻¹ and 1077 mg kg⁻¹ in FYM treated plants and 1101 mg kg⁻¹ and 1206 mg kg⁻¹ in combined application of urea and farm yard manure applied treatments in Samaru and Shika respectively. Nitrate concentration decreased with higher farm yard manure addition to urea fertilizer and no single application of anyone fertilizer increased spinach yield along with reduced nitrate accumulation. However, all nitrate concentration recorded were below the 3000 mg NO₃ kg⁻¹ limit of nitrate by the European Safety Union.

Keywords: Farm yard manure, urea fertilizer, nitrate concentration, spinach and growth attributes

INTRODUCTION

Spinach is a short season vegetable crop that is produced all year round in Nigeria. In the dry season, crop lands are established both along the flood plains and at high elevations with access to other irrigation means. Spinach production from the early times has provided employment and increased the income level of small scale farmers particularly in northern Nigeria where it is the main leafy vegetable nearly often used in all diets. However in the recent decade, apart from increase in population there have been spread of nutrition activities that involves intervention programs setup around the world that have increased awareness on proper nutrition practices, through sound counseling by medical and health workers to an extent there has been a shift in the diet of people and increased demand for leafy vegetables (FAOSTAT, 2024). However just like any other crop the production of spinach depends on several factors. Thus NTI (2003) reported limited knowledge and poor soil fertility to be among the main factors that is limiting spinach production in the country.



Results of several studies also indicated that spinach production with synthetic nitrogen fertilizer contain toxic compounds formed from the conversion of this element in to other products that reduce the quality of the crop in food preparation. It has been established that a 100gm serving of spinach contain anywhere between 24 to 387 mg of nitrate (depending on the growing condition of the crop) (Ramachandra et al 2005). Ingesting high levels of nitrate reduces the ability of the red blood cells to carry oxygen. Again when spinach is cultivated continuously using chemical fertilizers they are said to loose their biological values, smell and taste (Han et al, 2023). Thus the impact of various cultural practices might have knowingly or unknowingly been responsible for the enormous quantity of nitrate found in spinach vegetables.

The amount of nitrate-nitrogen required in the soil for specific crop varies from crop to crop, but in general unknown or unspecified amount of a certain fertilizer that exceed the level that should be applied are used. While only on few instances are organic substances meant to correct the soil to its original form or state are often used. Organic matter in the soil is often seen in the soil to serve as reservoir for plant nutrients. Hence this trial is meant to investigate the possible measures of producing spinach that conform with accepted standards without much compromise on yield.

MATERIALS AND METHODS

In 2019, experiments were conducted to evaluate the effect of organic and inorganic fertilizer application on the growth yield and level of nitrate content of spinach on the Teaching and Research Farm of the College of Agriculture, Division of Agricultural Colleges and Research Farm of the Institute for Agricultural Research (IAR), Ahmadu Bello University at Samaru (Latitude 11° 11' N, Longitude 07° 38' E) in the northern guinea savanna of Nigeria. The mean annual rainfall ranges between 600mm – 800mm. The highest mean monthly temperatures (30 – 40°) occur between November and March. At each site between 15 and 20 soil cores were taken at a depth of 30 cm using a soil auger 3 cm in diameter, on the diagonals of the experimental plots. Soil samples were bulked into composite samples. The samples were air dried, sieved and mechanically analysed using the hydrometer method described by Bouyoucos (1951); pH, using a pH meter with glass electrode total N, using macro-kjeldahl procedure described by Jackson (1958), extractable P determined using Bray-I method described by Bray and Kurth (1945), organic C determined using the method described by Walkley and Black (1934) and effective cation exchange capacity (ECEC) as described.

The result of the soil analysis are shown in Table 1. Shows fine sandy loam at Samaru (DAC) while at Shika, it was loam in texture. The soil pH was slightly alkaline at Samaru, but moderately acidic in Shika. The available phosphorus and organic carbon was low at Shika but moderately high at Samaru. In general the soils of Shika had lower CEC 3.89 cmol kg⁻¹) than Samaru (6.30 cmol kg⁻¹), while soil N was the same in both locations.

Table 1: Physical and chemical properties of 0-30 cm depth of the soil at the experimental sites during the 2019 at Samaru and Shika, Nigeria.

| Physical Properties | DAC Samaru Area | IAR Shika Area |
|---------------------------------------|-----------------|----------------|
| Sand (%) | 58.0 | 40 |
| Silt (%) | 30.0 | 32 |
| Clay (%) | 12.0 | 28 |
| Textural class | Sandy loam | Loam |
| Chemical properties | | |
| pH in H ₂ O | 7.30 | 5.65 |
| pH in 0.01M CaCl ₂ (1:2.5) | 7.00 | 4.60 |
| Organic carbon (g/kg) | 1.08 | 0.57 |
| Total Nitrogen (g/kg) | 0.36 | 0.33 |
| Available phosphorus (meq/kg) | 21.88 | 12.5 |
| Exchangeable cations (cmol/kg soil) | | |
| Potassium | 2.35 | 4.7 |
| CEC (meq/100 g) | 6.70 | 3.89 |

Table 2: Chemical composition of the farm yard manure at DAC Samaru and IAR Shika (oven dry basis)

| FYM Manure | Samaru | Shika |
|------------|--------|-------|
| N (%) | 1.73 | 1.15 |
| P (%) | 0.938 | 1.074 |
| K (%) | 1.70 | 1.25 |
| Na (ppm) | 0.20 | 0.65 |

A randomized complete block design, with three replications and ten treatments, was used. The treatments included three fresh farm yard manure (6,8 and 10 t ha⁻¹) rate three urea chemical fertilizer rates, (100, 150 and 200 kg N ha⁻¹) three combinations of urea chemical fertilizer and organic farm yard manure (cowdung) fertilizer rates and a control treatment (without any fertilizer).

The experimental site was ploughed, and harrowed twice and ridges were constructed 75cm apart each plot consisted of ridges 2.0 m long. The inner ridges were flattened with a small hoe to form planting basins. The spinach cultivar “alleyaho” popularly grown in the area was sown at spacing of 20cm x 20cm on 5th June 2019 at DAC and 10 June 2019 at IAR. The variety which is broad dark green leaves, characterized by a smooth texture with upright growing habit. Farm yard manure, based on treatments levels was applied on the 15th May 2019 at DAC and 20th May 2019 at IAR Shika.

All plots received a basal application of single superphosphate at the rate of 30 kg ha⁻¹ and muriate of potash at 30 kg ha⁻¹ which were incorporated into the soil before planting. Urea (46% N) was applied according to treatments in two equal split doses by band placement between rows. The vegetable was irrigated whenever dry spelt was observed.

Weed was controlled by spraying metalochlor at the rate of 1.0 kg a i ha⁻¹ 2 weeks before the final field preparation as pre-planting and later weed was controlled by hand pulling.

Harvesting: Using a hand sickle was used to harvest at 8 WAS from various plots and weighed using top loading electronic metler balance (model MT-301) with maximum weighing capacity of 300 g and minimum weight of 0.05 g.

From five randomly selected tagged plants excluding boarder rows the following parameters were measured at 4, 6 and 8 weeks after sowing. Plant height (cm) plant height was measured as the distance from the ground level to the highest point of a leaf.

Plant diameter (cm): This was determined by the measuring the thickness of the stem using a vanier caliper.

Leaves area: The perimeter of each leaf for the total number of leaves on each plant of 5 randomly tagged plant per plot was measured, by tracing the outline of leaves on blank sheets of paper and later the average was recorded.

Number of leaves: The number of leaves was recorded by counting total primary and fully developed leaves and the average was recorded.

Fresh weight kg plant⁻¹: The fresh weight was weighed using top loading electronic metler balance (model MT-301) with maximum weighing capacity of 300 g and minimum weight of 0.05 g.

Dry weight kg plant⁻¹: The dry weight was weighed after oven drying at 60°C using top loading sensitive balance.

Yield: Yield from five plants randomly selected from each net plot using a sensitive balance and the average recorded.

Data collected were subjected to statistical analysis of variance (ANOVA) as described by Snedecor and Cochran (1967). The difference s between treatment means was compared using Durcan Multiple Range Test (DMRT) Duncan (1955). All statistical procedures were done as described by Gomez and Gomez (1984).

The spinach NO₃ content was determined at 2, 6 and 8 weeks after planting with a spectrometer after micro-kjeldahl digestion of whole spinach samples which had been ground. The method is based on extracting the organic phase of the slurry previously fractionized with sodium hydroxide from which the absorbance was read from the spectrometer and use to calculate nitrate



contents in mg/g in the spinach using a formular. The results are expressed in milligram of nitrate per gram of fresh weight of the plant.

Fresh vegetable leaves of spinach was flushed and washed with flowing water and grinded using mortar and pestle till a homogenous slurry was formed and then between 10g and 20g of slurry were warmed at 80 °C for 25 mins and shaken. The solution was sieved at 200 µm, 50 µm and 0 – 50 µm. The 0 – 50 aliquot was cooled in ice then 5 % Ag₂ SO₄ solution was added followed by subsequent addition of 98% H₂SO₄ and 5 % phenol solution. The solution was allowed to stand for 20 min while shaking occasionally to have homogenous mixture. The resulting mixture was extracted in a 50cm separating funnel by addition toluene and shaking for 5 to 10 min. The lower aqueous layer was discarded and the organic phase was washed twice with 10 ml distilled water by shaking for 2 min and each time discarding the aqueous phase. Then the organic phase was extracted again by shaking for 1 min with 10 ml of 10% Na₂CO₃ solution and collected in a test tube. Then from the spectrometer the absorbance was read at 407 nm. Since 4 ml of the 100 ml filtrate was used for the analysis. The following formular:

$$\text{Nitrate} = \frac{C \times 100}{W_s \times 4} \text{ was used to calculate nitrate } \mu\text{g in the spinach}$$

Where C = concentration of nitrate in the sample.

W_s = Weight of slurry

RESULTS AND DISCUSSION

The data on plant height, plant diameter, number of leaves, leaf area, fresh weight, dry weight and yield in kg ha⁻¹ at Samaru (DAC) and Shika (IAR) are shown in Tables 3 and 4 respectively, maximum leaf area (21.53 cm²) was recorded in plot treated with urea fertilizer and was followed by plants treated with chemical fertilizer in combination with FYM (21.13 cm²) and plot applied with urea fertilizer (21.03), the minimum leaf area was noted in the control (11.28 cm²). However in Shika (IAR) maximum leaf area (20.84 cm²) was documented by plants applied with urea fertilizer and was followed by from urea fertilizer 200 kg N ha⁻¹ (20.69 cm²) and then urea fertilizer in combination with FYM (20.51 cm²).

The data on plant diameter indicated the maximum plant diameter (0.36cm) to be observed from both the plots applied with urea fertilizer (0.36 cm) and also by urea fertilizer in combination with FYM (0.36cm) and there after the plots applied with 3 ton ha⁻¹ FYM + 90 kg N ha⁻¹ (0.35 cm) whereas the least was in the control with 0.22 cm². In the other location (Shika) maximum plant diameter was observed in plots treated with 100 kg N ha⁻¹ (0.46 cm) and afterwards plot that received urea fertilizer 150 kg N ha⁻¹ (0.44 cm) and then plots treated with urea fertilizer in combination with FYM (0.42 cm) least plant diameter was indicated in the control (0.20 cm).

Plant height in the control was 7.59 cm, whereas the maximum height of plants was observed in plots treated with 200 kg N ha⁻¹ urea (12.95cm). However this was followed by the plants applied with 150 kg N ha⁻¹ (12.02cm) and then inorganic fertilizer in combination with organic fertilizer (11.32cm). In Shika (IAR) maximum plant height (12.42 cm) was discovered in plots treated with 150 kg N ha⁻¹ which was followed by urea fertilizer 200 kg N ha⁻¹ (12.16cm) and then chemical fertilizer in combination with organic fertilizer (11.50 cm) was in the plots applied with 6 ton ha⁻¹ FYM (8.54cm).

At Samaru (DAC) maximum vegetable yield was produced in plants grown with FYM in combination with urea (40, 222.0 kg ha⁻¹). It was followed by urea fertilizer of 150 kg N ha⁻¹ (39,587.92), 3 t ha⁻¹ FYM in combination with 90 kg N ha⁻¹ (39284.11). Whereas minimum vegetable yield (21,077.30 kg ha⁻¹) was recorded in the control without any fertilizer. Where as in Shika (IAR) the highest vegetable yield was obtained from plots treated with urea chemical fertilizer (36895.21 kg ha⁻¹), which was followed by FYM + urea fertilizer (36354.5 kg ha⁻¹), afterwards FYM + urea fertilizer (35813.05 ha⁻¹). The least vegetable yield (18,796.31) was observed in the control.

The maximum number of leaves was observed from plants grown with 100 kg N ha⁻¹ urea fertilizer (12.17) which was followed by urea fertilizer of 150 kg N ha⁻¹ (11.88) and FYM in combination with urea (11.59) while the minimum of that was in the control, but at Shika (IAR) the



maximum number of leaves was found in treatment of FYM + urea fertilizer (10.79), and was followed by urea fertilizer of 100kg N ha⁻¹ (10.73) then plants applied with 150 kg N ha⁻¹ of urea (10.70). The minimum number of leaves was from the control (6.26).

As shown in Tables 3 and 4 there was a very close relation between the response to single application of urea fertilizer to the combined application of urea fertilizer and FYM observed in the both locations. This is in the progressive increases observed by the two main fertilizer management practices occurring within the same range. Combined application of organic and inorganic fertilizer have been show to increase the morphological characters above any one or single application practice. However in this this case of leafy vegetable because it was the nitrogen ions have been show to decrease considerably to enable reduction in NO₃⁻ - N accumulation by addition of organic material improvement can only be judged in terms of nitrogen use efficiency since the improvement in the combined application of urea and FYM is not only ascribed to organic and inorganic N but also related to other functions of the organic material added, such as in the enhanced physical properties of the soil particularly when using fresh farm yard manure which is known to have a high C/N ratio.

Although the release of nutrients is important when considering the manorial quality of a material, the contribution of such a material to soil organic matter status is more important especially in vegetable crops where nitrate tend to accumulate easily.

The performance of spinach crops with the application of FYM was not significant compared with control even though there was improvements. The non-significant increases compared to control recorded in both growth and yield of spinach at harvest (8 WAS) may be due to the low fertility status of the soils of the study areas (Table 1) coupled with the low natural elements in the manure (Table 2). On the other hand the consistent significant variation in the effect of different type of fertilizer treatments (organic and inorganic) in this experiment in the both locations might be due to variation in the availability of their nutrients resources which in the case of FYM may not have been available at critical stages of growth to coincide with spinach uptake compared with nutrients supplied by urea, which assured rapid growth and improved vegetable yield from the initial growth stages. Chemical fertilizers offer nutrients which are easily soluble in soil solution which makes it immediately available to the plants.

The accumulation of NO₃-N in spinach plants grown on plots under the different treatments of urea and FYM fertilizer used at both locations were significantly different, indicating that nitrate accumulation may be accompanied by difference in nutrient composition. This lends credence to the fact that FYM are generally deficient in available nutrients. This could also have been responsible for the poor morphological performance of FYM compared to urea fertilizer treated plants, observed since the differences were significant.

The maximum nitrate accumulation (1527 mg kg⁻¹ and 1675 mg kg⁻¹) recorded for the inorganic fertilizer treated plants were 16.21 and 12.04 % more than the medium occurring (150 kg N ha⁻¹) and 1495 mg kg⁻¹ in urea inorganic fertilizer treatments at 6 WAS in both locations of Samaru (DAC) and Shika (IAR) area respectively. Rahamatullah et al (2019) who working on growth and nitrate content in lettuce by organic and inorganic fertilizers also reported the highest nitrate levels to be found in the medium and maximum inorganic fertilization 572-664 mg/kg of inorganic treatments compared to 253-432 mg/kg in the organic fertilizer treatments.

Samin et al (2010) also observed that organic material did not contribute nitrate (NO₃⁻ N) to the plant s while NO₃⁻ - N levels in plants that received inorganic ammonium nitrate were initially high but progressively declined as the fertilizer N became depleted.

It was recorded that highest NO₃ – N accumulation by spinach plants grown on plots treated with urea levels had 47.78 and 38.89 % higher NO₃⁻ - N accumulation than the highest occurring 775 mg kg⁻¹ and 702 mg kg⁻¹ in the combined application of urea fertilizer with farm yard manure recorded at 6 WAS at Samaru and Shika respectively (Table 5), while there was no specific differences in their agronomic performance between the urea alone treated plots and the urea fertilizer in combination with FYM treatment (Table 3 and 4). In the case nitrate accumulation by the highest occurring combined application of urea fertilizer and FYM in this research is in line with the work of Samin et al (2010) who reported the limited absorption of NO₃ in the growth components of

lettuce as a result of combined application of organic and inorganic fertilizer. At this point it is important to mention that this is apparently linked of the reduced levels of these compound in the material added. In another scenario Ramachandra et al (2005) reported that total mineral N (NH_4^+ and NO_3^-) in leachates of the experimental periods was markedly reduced by addition of C only when the C/N ratio exceeded 10:1 and the amount of added N was equivalent to approximately 50 kg N ha. He further stressed this was not the case at the lower amount of 10 kg N ha⁻¹ the level usually recommended when using the N- dilution method for estimation of nitrogen fixation. The implication of this finding is that firstly the efficiency of adding C upon the application of urea fertilizer will depend on the actual amount of native soil N mineralized. Secondly the higher the FYM addition in the combined treatments the lower the nitrate contents that will be found in the plant tissue until a balance is stricken when any more addition of C will result in decreased yield in kg ha⁻¹.

Table 3: Effect of farm yard manure and urea fertilizer on growth attributes and yield of spinach at DAC Samaru during 2019 wet season at 6 weeks after planting

| Treatment | Plant height (cm) | Plant diameter (cm) | Number of leaves | Leaf area Cm ² | Fresh weight kg plant ⁻¹ | Dry weight kg plant ⁻¹ | Yield kg ha ⁻¹ |
|---|-------------------|---------------------|------------------|---------------------------|-------------------------------------|-----------------------------------|---------------------------|
| Control | 8.59b | 0.22 | 6.085c | 11.28c | 2.69b | 1.01b | 21077.30 |
| FYM 6t ha ⁻¹ | 8.92b | 0.25 | 8.67b | 15.38b | 3.58b | 1.50b | 28728.8 ⁺ |
| FYM 8t ha ⁻¹ | 8.99b | 0.27 | 8.98b | 16.40b | 3.80b | 1.70b | 38635.20 |
| FYM 10t ha ⁻¹ | 9.22b | 0.25 | 9.27b | 15.38 | 3.58b | 1.49b | 28792.84 |
| 100 kg Nha ⁻¹ | 10.92b | 0.33 | 12.17a | 21.53a | 4.76a | 2.71a | 37023.76 |
| 150 kg Nha ⁻¹ | 12.02a | 0.36 | 11.88a | 21.03a | 5.20a | 2.99a | 39587.92 |
| 200 kg N ha ⁻¹ | 12.95a | 0.32 | 11.30a | 20.03a | 4.91a | 2.89a | 37416.51 |
| 3t ha ⁻¹ FYM + 90 kg Nha ⁻¹ | 11.32a | 0.35 | 11.59a | 21.13 | 4.99a | 2.96a | 39284.11 |
| 4t ha ⁻¹ FYM + 70/kgNha ⁻¹ | 11.48a | 0.36 | 11.30a | 19.82a | 5.12a | 3.07a | 40222.0 |
| 5t ha ⁻¹ FYM + 50kg Nha ⁻¹ | 10.92 | 0.34 | 11.59a | 20.53a | 5.05a | 2.88a | 38350.04 |
| SE ± | 0.698 | 0.103 | 0.504 | 1.849 | 0.401 | .411 | 5.510 |

SE = Standard error, Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability using DMRT. FYM = Farm yard manure

Table 4: Effect of farm yard manure and urea fertilizer on growth attributes and yield of spinach at Shika during 2019 wet season at 6 weeks after planting

| Treatment | Plant height (cm) | Plant diameter (cm) | Number of leaves | Leaf area (Cm ²) | Fresh weight kg plant ⁻¹ | Dry weight (kg plant ⁻¹) | Yield (kg ha ⁻¹) |
|----------------------------------|-------------------|---------------------|------------------|------------------------------|-------------------------------------|--------------------------------------|------------------------------|
| Control | 8.91b | 0.20 | 6.26c | 11.22c | 2.63b | 1.46 | 18796.31 |
| FYM 6t ha ⁻¹ | 8.54b | 0.28 | 7.37b | 14.89b | 3.31b | 1.65 | 25448.15 |
| FYM 8t ha ⁻¹ | 9.52b | 0.30 | 7.63b | 15.88b | 3.53b | 1.77 | 27304.55 |
| FYM 10t ha ⁻¹ | 9.44b | 0.28 | 7.88b | 14.88b | 3.31b | 1.65 | 25602.85 |
| 100 kg Nha ⁻¹ | 10.83a | 0.46 | 10.73a | 20.84 | 4.77a | 2.46 | 36895.21 |
| 150 kg Nha ⁻¹ | 12.42a | 0.44 | 10.70a | 19.71a | 4.63a | 2.38 | 35813.15 |
| 200 kg Nha ⁻¹ | 12.16a | 0.40 | 10.43a | 20.69a | 4.56a | 2.35 | 35271.60 |
| 3t FYM + 90 kg Nha ⁻¹ | 11.50a | 0.41 | 10.99a | 20.51a | 4.70a | 2.42 | 36354.5 |
| 4 t FYM + 70/kgNha ⁻¹ | 10.55a | 0.42 | 10.73a | 19.50 | 4.41a | 2.26 | 34711.35 |
| 5 t FYM + 50kg Nha ⁻¹ | 10.57a | 0.42 | 10.46a | 19.88a | 4.63a | 2.38 | 35813.05 |
| SE ± | 0.668 | 0.113 | 0.507 | 1.003 | 0.403 | 0.356 | 4.9611 |

SE = Standard error, Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability using DMRT. FYM = Farm yard manure

Table 5: Effect of farm yard manure and urea fertilizer on fresh weight and nitrate concentration in spinach at Samaru and Shika at 4, 6 and 8 weeks after planting

| Treatment | Fresh weight kg plant ⁻¹ | | | Nitrate contents (mg kg ⁻¹) | | |
|----------------------------------|-------------------------------------|----------|----------|---|----------|----------|
| | Weeks after planting | | | | | |
| Samaru | 4 | 6 | 8 | 4 | 6 | 8 |
| Control | 1.64 | 2.14b | 2.69b | 567b | 580c | 580c |
| FYM 6t ha ⁻¹ | 1.87 | 2.88b | 3.58b | 573b | 985b | 689b |
| FYM 8t ha ⁻¹ | 1.82 | 2.97b | 3.80b | 575b | 989b | 692b |
| FYM 10t ha ⁻¹ | 1.67 | 2.59b | 3.58b | 582b | 1001b | 700b |
| 100 kg Nha ⁻¹ | 2.42 | 3.73a | 4.76a | 974b | 1129b | 790b |
| 150 kg Nha ⁻¹ | 2.46 | 3.80a | 5.20a | 1207a | 1400a | 980a |
| 200 kg Nha ⁻¹ | 2.41 | 3.84a | 4.91a | 1317a | 1627a | 1168a |
| 3t FYM + 90 kg Nha ⁻¹ | 1.96 | 3.47a | 4.99a | 640c | 1101b | 770b |
| 4t FYM + 70/kgNha ⁻¹ | 2.15 | 3.50a | 5.12a | 632c | 1087b | 760b |
| 5t FYM + 50kg Nha ⁻¹ | 2.30 | 3.59a | 5.05a | 630c | 1083b | 758b |
| SE ± | 0.255 | 0.385 | 0.401 | 70.212 | 81.401 | 56.911 |
| Shika | 4 | 6 | 8 | 4 | 6 | 8 |
| Control | 1.70 | 2.04bc | 2.63b | 586c | 598c | 598d |
| FYM 6t ha ⁻¹ | 1.78 | 2.67b | 3.31b | 596c | 1045b | 717c |
| FYM 8t ha ⁻¹ | 1.96 | 2.83ab | 3.53b | 614c | 1056b | 739c |
| FYM 10t ha ⁻¹ | 1.74 | 2.49b | 3.31b | 638c | 1077b | 747c |
| 100 kg Nha ⁻¹ | 2.50 | 3.67a | 4.77a | 1113b | 1275b | 922b |
| 150 kg Nha ⁻¹ | 2.51 | 3.70a | 4.63a | 1289a | 1495a | 1046a |
| 200 kg Nha ⁻¹ | 2.58 | 3.69a | 4.56a | 1444a | 1675a | 1172a |
| 3t FYM + 90 kg Nha ⁻¹ | 2.32 | 3.03a | 4.70a | 701c | 1206b | 844b |
| 4t FYM + 70/kgNha ⁻¹ | 2.40 | 3.51a | 4.41a | 675c | 1161c | 812b |
| 5t FYM + 50kg Nha ⁻¹ | 2.34 | 3.51a | 4.63a | 655c | 1127c | 788b |
| SE ± | 0.275 | 0.280 | 0.303 | 73.102 | 84.752 | 59.301 |

SE = Standard error, Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability using DMRT. FYM = Farm yard manure

CONCLUSION

The experiment was conceived to improve spinach cultivation with reduced nitrate concentration. The result revealed that no single nutrient application controlled nitrate accumulation and gave the maximum yield as well. All combinations of urea fertilizer with farm yard manure proportionately improved spinach yield and reduced nitrate concentration.

REFERENCES

- Bagshaw, J., Moody, P., and Pattison T. (2010). Soil Health for vegetable production in Australia. Department of employment, Economic Development and Innovation.
- Bonyoucos, G.H. (1951). A Calibration of the Hydrometer for main mechanical analysis of soils. *Agronomy Journal* 43: 434-38.
- Bray, R.H. and Kurth, L.T. (1945). Determination of total organic and available forms of phosphorus in soils: *Soil Sci.* 59: 39-45.
- Cassaman, K.G. and Muns, D.N. (2000). Nitrogen mineralization as affected by soil moisture, temperature and depth. *Soil science society. American Journal* 104:1233-37.
- Duncan D.B. (1955). Multiple Range and Multiple F- test, *Biometrics* 11, 1-42.
- Elsayed A. A. Abdelraouf (2016). The Effects of Nitrogen Fertilization on Yield and quality of Spinach grown in High tunnels Alexandria Science Exchange Journal, vol. 37. No. 3 P. 488 – 496
- Fagbenro, J.A. (1988). Studies on the extraction of soil organic matter and the effect of humic acid on the growth of teak (*Tectona grandis* L) seedlings PhD Thesis, Department of Agronomy, University of Ibadan, Nigeria.



- FAOSTAT, (2024). Food and Agriculture Data (FAOSTAT) 2024 Food and Agriculture database.
- Giller, K. E. and Witty, J. F. (1087). Immobilized N fertilizer sources improve the accuracy of field estimates of N₂ fixation by isotope dilution. *Soil Biology and Biochemistry* 19: 459-63.
- Gomez, K. A. and A. A. Gomez, (1984). *Statistical Procedures for Agricultural Research* 2nd Edn. John Wiley and Sons Inc, New York, U.S.A. ISBN: 13-9780471879312, pages: 680
- Han, K., Zhang, J., Wang, C., Yang, Y., Chang, Y, Gao, Y. (2023). Changes in growth, physiology and photosynthetic capacity of spinach (*Spinacia oleracea* L) under different nitrate levels. *PLOS ONE* 18 (3) 0283787.
- [http://www.agriclinics.net/ACCABC Guidelines 2018, pdf.](http://www.agriclinics.net/ACCABC%20Guidelines%202018.pdf)
- [https://www.fao.org/faostat/en/#data.](https://www.fao.org/faostat/en/#data)
- Jackson M. I. (1958). *The soil chemical analysis*. London UK; Constable.
- NTI (2003). National Institute of Agricultural Extension (An Organization of Ministry of Agriculture & Farmers Welfare, Government of India).
- Rahmatullah, H., Abdul K. A., Mujeeb, R. K. and Hukum K. H. (2019). Effect of Organic and inorganic fertilizers levels on spinach (*spinacia oleracea* L) production and soil properties in Khos Province, Afghanistan. *Internal Journal of Applied Research* 2019: 5 (7): 83-87.
- Ramachandra A., Hrycan, W., bantle, J. and Waterer, D. (2005). Seasonal Changes in tissues nitrates levels in fall-planted spinach (*spinacia, oleracea*) Research Report available <http://www.usuask.ca/agricultureplantsc/vegetable>.
- Samin A., Taleb, A. Z., Yasin, A. A. Tarek, G. A. (2010). Nitrate accumulation in Spinach (*Spinacia oleracea* L) tissues under different fertilizations regimes. *Journal of Food Agriculture & Envi.* 8 (2): 778-780.
- Snedecor, G. W. ad Cochran, W. G. (1967). *Statistical methods* 6th edition, Ames, Iowa, the. Iowa State University.
- Walkley, A. and Black, I. A. (1934). An examination of degtjarf method for determination of soil organic matter and a proposed modification of the chromic acid titration method, *soil Sci.* 37: 29-38.