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**Varikuppala Manisha**
Research Scholar, Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

**Arun Alfred David**
Associate Professor, Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

**Tarence Thomas**
Professor, Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

**Narendra Swaroop**
Associate Professor, Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

**Amreen Hasan**
Assistant Professor, Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

**Corresponding Author:**
**Varikuppala Manisha**
Research Scholar, Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

# Effect of integrated nutrient management practices on soil health, quality and yield of spinach (*Beta vulgaris* L.) grown on alluvial soil

**Varikuppala Manisha, Arun Alfred David, Tarence Thomas, Narendra Swaroop and Amreen Hasan**

## Abstract
An experiment entitled "Effect of Integrated Nutrient Management practices on soil health, quality and yield of spinach (*Beta vulgaris* L.) Grown on Alluvial soil" was carried out during Zaid season (2021) at the Crop Research Farm, Department of Soil Science and Agricultural Chemistry, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh. The experiment was laid out in a randomized block design (RBD) with 9 different INM treatments with three replications involving 100% recommended dose of nutrients through inorganic and organic, integrated treatments of 0%, 50%, 100% of recommended dose of inorganic fertilizer and also boron along with 0%, 50%, 100% Organic manure *viz.*, farm yard manure, and bio fertilizer (PSB @ 2 kg $ha^{-1}$). Of all treatments $T_9$ RDF + @ 100% (FYM + PSB) + @ 100% B has shown significant improvement in growth and yield parameters than other treatments. The treatments recorded the highest plant height 22.62 cm, number of leaves 12.38 on 30 DAS over the control treatment and yield parameter *viz.*, fresh weight of plant per plot 2.27 kg, dry weight of plant 5.1g, and yield per hectare 74.00 q $ha^{-1}$. The $T_9$ was superior among all treatments under investigation for response spinach production.

**Keywords:** Nutrient, spinach, growth, yield, P.S.B., FYM, boron, etc.

## Introduction
Malnutrition, undernourishment, protein and vitamin deficiencies, and diseases are the most haunting problems of the population in India. To meet the growing requirements of the vegetarian society and the challenges of production of quality vegetables, particularly leafy vegetables this improves the health wealth of people. There is a need for improvement in the crop integrated nutrient management practices to ensure better quality as well as production.
Among the leafy vegetables Spinach (*Beta vulgaris* L.) var*; bengalensis* commonly known as 'Indian spinach' in English and 'Palak' in Hindi, originated from Indo-Chinese region belongs to the genus *Beta*, specie *vulgaris* and family Chenopodiaceae. Leaves of this might have been first used in Bengal and hence known as *var. bengalensis*. It is also called as Beet leaf and Desi palak. It is closely related to beet root, sugar beet, and Swiss chard. Sea beet *(Beta vulgaris var. maritima)* is the ancestor of palak. It is commonly grown for its tender and soft succulent leaves Jabeen *et al.,* (2018). Area covered by spinach in India was 840 ha Anon (2017) [2]. Indian spinach leaves are valued for its medicinal properties and used in inflammation, paralysis, headache and remedy for disease of spleen and liver. It also acts as mild laxative besides other medicinal values.
Spinach is commonly grown in all soil types and is one of the most popular leafy vegetables with high calorific values. They are rich in mineral and hence can be called as "mines of minerals" Singh *et al.,* (2015) [13]. The popular palak growing states include Uttar Pradesh, West Bengal, Maharashtra and Gujarat. However, Palak is not very popular in South India. It is primarily used as potherb. It is a cheap and rich Source of vitamin A, which helps in eyesight. It is also a good source of vitamin C and mineral elements like phosphorous, calcium and iron which are important from the health point of view of human beings. The leaves contain low oxalic acid. Spinach contains 246.60 nitrogen, 46.80 phosphorous, 121.24 potash, 293.20 calcium, 36.03 iron and ascorbic acid content of 23.58 mg $100g^{-1}$ and carotene content of 37.50g $100g^{-1}$ of edible portion.
Modern nutrient management strategy has shifted its focus towards the concept of sustainability and eco-friendliness. Intensive use of only chemical fertilizers to achieve high production has created various problems.

Continuous application of heavy doses of chemical fertilizers without organic manures or bio fertilizers has led to a deterioration of soil health in terms of physical and chemical properties of soil, declining of soil microbial activities, reduction in soil humus, increased pollution of soil, water and air. Hence, considering the economy, environment friendliness and maintain better soil health, it is imperative that plant nutrients are to be used effectively by adopting the integrated nutrient management practices. The basic principle behind this concept is to supply both the chemical fertilizers and organic manures for a sustainable crop production in most efficient manner, although the modern technique of intensive crop production needs the use of chemical fertilizers. Keeping this in mind the experiment was undertaken to find the effect of INM on growth, yield and quality of spinach.

## Materials and Methods

The investigation was carried out at the Crop Research Farm of the Department of Soil Science and Agricultural Chemistry Naini Agricultural Institute, SHUATS, Prayagraj (U.P) India during Zaid season (2021). The different INM nine treatments comprising of Farm yard manure (FYM), Phosphorous Solubilizing Bacteria (PSB), Boron along with RDF were experimented in Randomized Block Design (RBD) with three replications spinach beat cv, 'All Green' were sown in march first week in plot size of 1.00 × 1.00 m with spacing 20× 10 cm. The cuttings were made leaving the plants 5cm from base. All recommended package and practices were followed to raise good crop. The experimental plants were regularly observed and the data were recorded on plant height, number of leaves. The surface area for the collection of soil was cleared out. A hole was dug in a "V" shaped with the help of a spade, depth was measured by using a meter scale. Unwanted materials were removed. Soil samples were taking from depth i.e. 0-15cm. soil samples are taking from field leading to the collection of 27 samples in total. After collection, the soil was spread in sheet and air dried at room temperature away from direct sunlight. The soil clods or lumps are broken down into a fine particle with wooden mallet. The soil sample was sieved with 2mm sieve. The soil sample were collected by coning and quartering method. The collected soil was kept in a clean and dry polythene bag. The soil was analyzed by using standard methods: texture by Bouyoucos Hydrometer method (Bouyoucos, 1927) [4]. Soil colour by Munsell soil colour chart (Munsell, 1954). Specific gravity by relative density bottle or Pycnometer (Black, 1965).For bulk density, particle density, water holding capacity and percentage pore space by Graduated 100 ml measuring cylinder method (Muthuaval *et al.*, 1992) [9], Soil pH by Digital pH Meter (Jackson 1958) [7], Electrical Conductivity by Digital EC Meter (Wilcox 1950) [18], Organic Carbon by Wet Oxidation Method (Walkley and Black 1947) [17], Available Nitrogen by Alkaline Permanganate method by using Kjeldahl Flask (Subbiah and Asija 1956) [14], Available Phosphorous by Spectrometric method Olsen (alkaline neutral) and Bray (acidic) (Olsen and Bray 1954) [10] Available Potassium by Flame Photometer Method using ammonium acetate solution (Toth and Prince 1949) [15].

## Results and Discussion

As presented in the table 1 Bulk density (Mg $m^{-3}$) was recorded there was significant effect of different treatments. Treatment $T_1$ Absolute control recorded maximum 1.27 followed by 1.26 with $T_2$ RDF+ @ 0% (PSB+FYM) +50% B. T9 RDF + @100% (PSB+FYM) + 100% B recorded the minimum 1.17.The bulk density is influenced by various treatments, when subjected to statistical analysis suggested that the response of integrated nutrient management gave significant difference in case of bulk density. Particle density (Mg $m^{-3}$) of soil as influenced by various treatments. The response Particle density of soil was found to be significant in levels of various treatments. The maximum Particle density of soil was recorded 2.34Mg $m^{-3}$ in treatment $T_1$ control and minimum Particle density of soil was recorded 2.46 Mg $m^{-3}$ in treatment $T_9$ RDF + @100% (PSB +FYM) +100% B. Similar results were also reported by Rana *et al.* (2010)

And the pore space (%) recorded at harvest that there was significant effect of different treatments. Treatment $T_9$ RDF + @100% (PSB +FYM) +100% B recorded maximum 50.51, respectively followed by T8 with 49.84. $T_1$ Control recorded the minimum 43.95, Pore space (%) It contains higher amount of organic materials and indicated an enrichment of fine fractions i.e. leading to change in physical properties of soil. The water retaining capacity recorded at harvest that there was significant effect of different treatments. Treatment $T_9$ RDF + @100% (PSB +FYM) +100% B recorded maximum 59.01 respectively followed by 56.28 $T_8$ RDF + @100% (PSB +FYM) +50% B. $T_1$ Control recorded the minimum with 47.98. Similar results were also reported by Rana *et al.* (2010).

**Table 1:** Effect of Integrated Nutrient Management of physical properties of post-harvest soil of spinach

| Treatments | Bulk Density (Mg $m^{-3}$) | Particle Density (Mg $g^{-3}$) | Pore pace (%) | Water Retaining Capacity (%) |
|---|---|---|---|---|
| $T_1$ Absolute control | 1.27 | 2.34 | 43.95 | 47.98 |
| $T_2$ RDF + @) 0% (PSB+FYM) + @50% B | 1.26 | 2.35 | 44.83 | 48.97 |
| $T_3$ RDF + @ 0% (PSB+FYM) + @ 100% B | 1.25 | 2.36 | 45.64 | 53.56 |
| $T_4$ RDF + @ 50% (PSB+FYM) +@ 0% B | 1.24 | 2.37 | 45.86 | 54.23 |
| $T_5$ RDF + @ 50% (PSB + FYM) + @50% B1 | 1.22 | 2.40 | 46.32 | 54.45 |
| $T_6$ RDF + @ 50% (PSB +FYM) + @100% B | 1.22 | 2.43 | 48.01 | 55.75 |
| $T_7$ RDF +@100% (PSB +FYM) + @0% B | 1.20 | 2.43 | 49.28 | 55.73 |
| $T_8$ RDF + @100% (PSB +FYM) +@ 50% B | 1.18 | 2.45 | 49.84 | 56.28 |
| $T_9$ RDF +@ 100% (PSB +FYM) + @100% B | 1.17 | 2.46 | 50.51 | 59.01 |
| S. Em. (±) | 0.00633 | 0.01052 | 0.66161 | 1.49889 |
| C.D. at 5% | 0.01907 | 0.03167 | 0.99164 | 4.5121 |

The maximum pH (1:2) of soil was recorded 7.48 in treatment $T_9$ RDF + @100% (PSB +FYM) +100% B followed by respectively $T_8$ with 7.41 and minimum pH of soil was recorded 7.10 in the treatment $T_1$ control. Similar results were also reported by John *et al.* (1999)**,** EC recorded at harvest that there was significant effect of different treatments. Treatment $T_9$ RDF + @100% (PSB +FYM) +100% B recorded maximum 0.49 respectively. T1 Control recorded the minimum 0.34. Organic carbon recorded at harvest that there was significant effect of different treatments. Treatment $T_9$ RDF + @100% (PSB +FYM) +100% B recorded maximum 0.62 respectively followed by 0.60 with $T_8$ RDF + @100% (PSB + FYM) + 50% B. $T_1$ Control recorded the minimum 0.40. Organic carbon improved the physical condition of soil and increased the water holding capacity of soil. It also promoted a greater proportion of pore size and improved aeration status of soil. The presence of dissolved organic matter caused to increase in soil organic carbon. Similarly findings also reported by Ngole (2010), Available Nitrogen recorded at harvest that there was significant effect of different treatments. Treatment $T_9$ RDF + @100% (PSB + FYM) + 50% B recorded maximum 281.23 respectively followed by 279.59 with $T_8$ RDF + @100% (PSB + FYM) + 50% B. $T_1$ Control recorded the minimum 240.28. Nitrogen promoted vegetative growth and improved the quality of produce including of this leafy vegetable and food crop. When nitrogen is present sufficient amounts in soil, plant growth of leaves healthy green color and normally gave high yield, nitrogen is delays reproductive growth and may adversely affect fruit and grain duality. A nitrogen deficiency plant ripens pre maturely and crop gives poor yield. Similar findings were also recorded, Phosphorous (kg $ha^{-1}$) of soil as influenced by different treatments. The minimum Phosphorous (kg $ha^{-1}$) of soil was recorded 16.63 kg $ha^{-1}$ in treatment $T_1$ control and maximum Phosphorous (kg $ha^{-1}$) of soil was recorded 23.34 kg $ha^{-1}$ in treatment $T_9$ RDF + @100% (PSB + FYM) + 100%**,** Ali *et al.* (2013) [1] Available Potassium recorded at harvest that there was significant effect of different treatments. Treatment $T_9$ RDF + @100% (PSB + FYM) + 100% B recorded maximum 241.77 respectively. $T_1$ Control recorded the minimum 224.56**.** In boron (kg $ha^{-1}$) Treatment $T_9$ RDF + @100% (PSB + FYM) + 100% B recorded maximum 0.91 respectively. $T_1$ (Control) recorded the minimum (0.48). Similar findings were reported by Sarkar *et al.*, (2017) [12].

**Table 2:** Effect of integrated Nutrient Management of Chemical properties of post-harvest soil of spinach

| Treatments | pH (1:2) | EC ($dSm^{-1}$) | OC (%) | N (kg $ha^{-1}$) | P ($kgha^{-1}$) | K ($kgha^{-1}$) | B (mg kg-1) |
|---|---|---|---|---|---|---|---|
| **T1** | 7.10 | 0.34 | 0.40 | 240.28 | 16.63 | 224.56 | 0.48 |
| T2 | 7.20 | 0.35 | 0.46 | 259.36 | 18.38 | 226.03 | 0.56 |
| T3 | 7.22 | 0.35 | 0.49 | 261.33 | 21.06 | 230.11 | 0.60 |
| T4 | 7.25 | 0.40 | 0.50 | 260.51 | 21.18 | 230.56 | 0.68 |
| T5 | 7.26 | 0.40 | 0.52 | 263.90 | 21.33 | 233.69 | 0.70 |
| T6 | 7.27 | 0.41 | 0.58 | 275.603 | 21.70 | 232.56 | 0.76 |
| T7 | 7.30 | 0.44 | 0.59 | 278.46 | 21.39 | 232.98 | 0.81 |
| T8 | 7.41 | 0.44 | 0.60 | 279.59 | 22.86 | 239.51 | 0.86 |
| T9 | 7.48 | 0.49 | 0.62 | 281.23 | 23.54 | 241.77 | 0.91 |
| S.Em(±) | 0.0164 | 0.00821 | 0.01279 | 1.65773 | 0.51591 | 3.87448 | 0.01913 |
| C.D at 5% | 0.4937 | 0.02472 | 0.03836 | 4.99024 | 1.55304 | 11.6633 | 0.05759 |

As depicted in table 3 has the significantly maximum plant height 10.5 cm, 22.62 cm, 29.04 cm was recorded in $T_9$ RDF + @ 100% (PSB + FYM) + @ 100% B. The treatment $T_8$ 27.71 cm, $T_7$ 26.50 cm were at par with treatment $T_9$ whereas, minimum plant height 7.13 cm, 16.44 cm and 23.24 cm was recorded in $T_1$ control. Nitrogen promotes vegetative growth through cell elongation a part from cell division and expansion. Phosphate solubilizing bacteria insoluble soil phosphate produce plant growth Phosphorous has great role in energy storage and transfer it is closely related to cell division and development. Phosphorous improve the quality of certain leaves vegetable crop and increase disease resistance of crop. The results obtained are in close confirmation with findings of Roy *et al.*, (2009) [11]. Similarly, significantly maximum number of leaves $plant^{-1}$ 4.96, 12.38 and 17.48 was recorded in $T_9$ RDF + @ 100% (PSB + FYM) + @ 100% B followed by $T_8$ 16.88 and minimum number of leaves/plant 3.53, 8.53 and 10.05 was recorded in $T_1$ control.

**Table 3:** Effect of Integrated Nutrient Management on growth parameters of spinach

| Treatments | Plant height (cm) | | | Number of leave $plant^{-1}$ | | |
|---|---|---|---|---|---|---|
| | 15 DAS | 30 DAS | 45 DAS | 15 DAS | 30 DAS | 45 DAS |
| $T_1$ Absolute control | 7.13 | 16.44 | 23.24 | 3.53 | 8.53 | 10.05 |
| $T_2$ RDF + @) 0% (PSB+FYM) + @50% B | 7.19 | 16.55 | 23.44 | 3.65 | 8.82 | 11.01 |
| $T_3$ RDF + @ 0% (PSB+FYM) + @ 100% B | 7.27 | 17.79 | 23.62 | 3.80 | 9.33 | 11.58 |
| $T_4$ RDF + @ 50% (PSB+FYM) +@ 0% B | 7.30 | 18.89 | 23.83 | 3.98 | 9.89 | 12.63 |
| $T_5$ RDF + @ 50% (PSB + FYM) + @50% B | 7.65 | 19.83 | 23.43 | 4.13 | 9.96 | 13.77 |
| $T_6$ RDF + @ 50% (PSB +FYM) + @100% B | 7.98 | 20.47 | 25.08 | 4.20 | 10.54 | 14.91 |
| $T_7$ RDF +@100% (PSB +FYM) + @0% B | 8.24 | 21.24 | 26.50 | 4.48 | 10.61 | 16.16 |
| $T_8$ RDF + @100% (PSB +FYM) +@ 50% B | 9.09 | 21.64 | 27.71 | 4.66 | 11.08 | 16.88 |
| $T_9$ RDF +@ 100% (PSB +FYM) + @100% B | 10.50 | 22.62 | 29.04 | 4.96 | 12.38 | 17.48 |
| S. Em. (±) | 0.21075 | 0.302502 | 0.33741 | 0.0566 | 0.20788 | 0.41886 |
| C.D. at 5% | 0.63441 | 0.91069 | 1.01572 | 0.17037 | 0.62577 | 1.2609 |

In case of fresh weight of the plant, treatment $T_9$ recorded maximum fresh weight of plant per plot 2.27 kg $plot^{-1}$, whereas $T_1$ recorded minimum 1.20 kg $plot^{-1}$. Maximum dry weight 5.10 g was found in $T_7$ which was at par with $T_8$ 4.54 g. Whereas, $T_1$ showed the minimum dry weight 2.74 g. The better efficiency of integrated nutrient management might be due to the availability of nutrients at an optimum level and microbial activity in the soil. Plants get nutrients throughout the growing period which led to higher fresh and dry weight of leaves plant. Similar findings were also reported by Vethamoni *et al.*, (2018) [16]. Significantly maximum 74.05, 58.83 $qha^{-1}$.

Leaves yield was noted under $T_9$ RDF + @100% (PSB + FYM) + @ 100% B and minimum followed by $T_1$ Absolute control. The increment of yield could be ascribed to additive effect of both sources of nutrient (organic and inorganic). Similar findings was also reported by Gore *et al.*, (2019).

**Table 4:** Response integrated nutrient management on yield parameters of spinach

| Treatments | fresh weight of plant Per plot (kg) | dry weight of plant (g) | leaf yield (q $ha^{-1}$) | |
|---|---|---|---|---|
| | | | 30 DAS | 45 DAS |
| **$T_1$ Absolute control)** | **1.2** | **2.74** | **48.00** | **30.17** |
| $T_2$ RDF + @) 0% (PSB+FYM) + @50% B | 1.28 | 2.99 | 52.07 | 37.45 |
| $T_3$ RDF + @ 0% (PSB+FYM) + @ 100% B | 1.31 | 3.43 | 55.27 | 40.44 |
| $T_4$ RDF + @ 50% (PSB+FYM) +@ 0% B | 1.39 | 3.84 | 58.01 | 43.15 |
| $T_5$ RDF + @ 50% (PSB + FYM) + @50% B | 1.42 | 4.06 | 60.66 | 43.80 |
| $T_6$ RDF + @ 50% (PSB +FYM) + @100% B | 1.56 | 4.17 | 62.08 | 44.71 |
| $T_7$ RDF +@100% (PSB +FYM) + @0% B | 1.59 | 4.43 | 64.83 | 46.51 |
| $T_8$ RDF + @100% (PSB +FYM) +@ 50% B | 1.68 | 4.54 | 67.28 | 48.30 |
| $T_9$ RDF +@ 100% (PSB +FYM) + @100% B | 2.27 | 5.1 | 74.05 | 58.83 |
| S. Em. (±) | 0.4708 | 0.07627 | 0.97167 | 2.89062 |
| C.D. at 5% | 0.14174 | 0.22958 | 2.92503 | 8.70163 |

Hence it can be concluded that, integrated use of chemical fertilizers along bio fertilizers is beneficial for growth, yield parameters over the sole use of any of the source of nutrition. The integrated nutrition containing $T_9$ RDF + @ 100% (PSB + FYM) + @ 100% B is superior to all treatments and suited in order to obtain higher yield of better quality of spinach.

## References


1. Ali AH, Hafez MM, Mahmoud AR, Shafeek MR. Effect of bio and chemical fertilizers on growth, yield and chemical properties of spinach plant (*Spinacia oleracea* L.). Middle East Journal of Agriculture Research 2013;2(1):16-20.
2. Anonymous. Area of Spinach Horticultural Statistics at a glance. Ministry of Agriculture and Farmer's welfare 2017, 389.
3. Black CA. Methods of Soil Analysis, American Society of Agronomy, Madison, Wisconsin, USA 1965.
4. Bouyoucos GJ. The hydrometer as the new method for the mechanical analysis of the soils, Journal of Soil Science 1927;2:343-353.
5. Gore AM, Paithankar DH, Deshmukh HK, Dange AM. Integrated Nutrient Management in Indian Spinach (*Beta vulgaris var. Bengalensis).* Indian Horticulture journal 2016;6(1):2249-6823.
6. Jabeen A, Narayan S, Hussain K, Khan FA, Ahmad A, Mir SA. Organic production of spinach beet (*Beta vulgaris var. bengalensis*) through the use of manures and biofertilizers. Journal of Pharmacognosy and Phytochemistry 2017;6(6):2278-4136.
7. Jackson ML. Soil Chemical Analysis, Prentice – Hall India, New Delhi 1958.
8. Jhon J, Kelly A, Max Haggblom B, Robert L. Effect of the land application of sewage sludge on heavy metal concentration and soil microble communities. Department of Enviornment Science, Rutgers 1999, 1467-1470.
9. Muthuaval PC, Udaysooriyan R, Natesa PP, Ramaswami. Introduction to Soil Analysis, Tamil Nadu Agriculture University, Coimbatore- 641002. Muche, M., Kokeb, A. and Molla, E. Assessing the Physiochemical Properties of Soil Under Different Land Use Type 1992.
10. Olsen SR, Cole CV, Watnahe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate, U. S. Department of Agriculture Circular 1954, 939.
11. Roy OP, Saha BK, Chowdhury MAH. Integrated nutrient management of spinach. Journal of Agroforestry and Environment 2009;3(1):57-60.
12. Sarkar RK, Jana JC, Datta S. Effect of boron and zinc application on growth, seed yield and seed quality of water spinach (Ipomoea reptans Pior.) under terai region of West Bengal. Journal of Applied and Natural Science 2017;9(3):1696-1702.
13. Singh GP, Meena ML, Prakash J. Effect of different levels of nitrogen an cuttings on growth, leaf yield and quality of spinach beet (*Beta vulgaris var. begalensis*) cv. ALL GREEN. European Journal of Biotechnology and Bioscience 2015;3(6):2321-9122.
14. Subbiah BV, Asija CL. A rapid procedure for the estimation of available nitrogen in soils, Current Science 1956;25:259-260.
15. Toth SJ, Prince AL. Estimation of cation exchange capacity and exchangeable Ca, K and Na content of soil by flame photometer technique. Soil science 1949;67:439-445.
16. Vethamoni P, Thampi SS. Effect of Organic Manuring practices on growth and yield of palak (*Beta vulgaris* var. *bengalensis* Hort.). International Journal of Current Microbiology and Applied sciences 2018;7(8):1855-1863.
17. Walkley A, Black IA. Critical examination of rapid method for determining organic carbon in soils, effect of variation in digestion conditions and of inorganic soil constituents, Soil Science 1947;632:251.
18. Wilcox LV. Electrical Conductivity. American Water works Association Journal 1950, 42-776.