



# The Impact of Integrated Nutrient Management on Growth and Yield of Palak (Indian Spinach)

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## **Authors' contributions**

*This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.*

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## **ABSTRACT**

Integrated nutrient management system is an alternative system for the sustainable and cost-effective management of soil fertility by combined apply of inorganic with organic materials resulting in rising soil fertility and productivity without affecting environment. Keeping in this view the present investigation was carried out at Polyhouse of Dr. B.R. Ambedkar university of social science Mhow, Indore (M.P.) during 2022 to study "The impact of integrated nutrient management on growth and yield of Palak (Indian Spinach)". Experiment was laid out in randomized complete block design with 4 replications. The experiment comprised of 6 treatments i.e. T1 (75% RDF through inorganic fertilizers + 25% RDF through VC), T2 (75% RDF + 25% RDF through FYM), T3 (50% RDF + 50% RDF through VC), T4 (50% RDF + 50% RDF through FYM), T5 (100% RDF only inorganic), T6 (Control or without any fertilizers). All observations were recorded at 30, 45 and 60 days after sowing (DAS). The results shows that the highest value of plant height (20.16, 29.77 and 44.69 cm), number of leaves plant-1 (12.07, 21.57 and 37.82), leaf width (4.83, 4.91 and 8.58 cm), leaf length

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(9.48, 22.10 and 23.24 cm), length of petiole (6.56, 9.27 and 10.89 cm), dry and fresh weight (4.49, 9.32 and 19.59 g) were recorded with the application of T5 (100% RDF) which was significant over T1 (75% RDF + 25% RDF through VC) and T2 (75% RDF + 25% RDF through FYM) and at par with T3 (50% RDF + 50% RDF through VC) at 30, 45 and 60 DAS. Similarly maximum yield (95.87, 95.48 and 90.20 q ha<sup>-1</sup>) was recorded with the application of T5 (100% RDF) which was significant over T1 (75% RDF + 25% RDF through VC) and T2 (75% RDF + 25% RDF (FYM) and at par with T3 (50% RDF + 50% RDF Vermicompost). Application of T3 (50% RDF + 50% RDF through VC) was also found significant over T4 (50% RDF + 50% RDF through FYM), T1 (75% RDF + 25% RDF through VC) and T2 (75% RDF + 25% RDF through FYM) with the values of 94.84, 94.00 and 88.77 q ha<sup>-1</sup> at 30, 45 and 60 DAS. Among all treatment application of T3 (50% RDF + 50% RDF through VC) gave maximum yield which not only increase yield but also save cost of 50% RDF. Therefore, organic and inorganic fertilization may have a significant positive impact on the growth and yield of Palak.

**Keywords:** *Recommended doses of fertilizers (RDF); vermicompost (VC); farmyard manure (FYM); integrated nutrient management (INM).*

## 1. INTRODUCTION

"Fruits and vegetables are rich source of vitamins and minerals that help strengthen the human immune system which in return and responsible for fighting against diseases. Vegetables play a significant role in Indian vegetarian diets. Palak is one of the most popular leafy vegetables with good nutritive value. It is a commonly grown leafy vegetable throughout the tropical and subtropical regions in all types of soils" [1]. "It contains 268.60 mg nitrogen, 49.68 mg phosphorus, 141.68 mg potash, 368.00 mg calcium, 42.32 mg iron, 50.24 mg ascorbic acid and 52.00 µg carotene content per 100 g of edible portion". [2]. Thus, it is called as "Mines of Minerals" [2]. "Spinach is very sensitive to N fertilization and it is one of the highest nitrate (NO<sub>3</sub>) accumulator's" [3,4,5]. "With an intention to increase the yield of greens, farmers are tempted to apply higher quantities of nitrogenous fertilizers, which may lead to accumulation of anti-nutrient factors in the greens beyond permissible limit" [6]. "Excessive accumulation of nitrates in vegetables is a common issue that poses a potential threat to human health and can cause gastric cancer and methemoglobinemia in infants and children" [7,8,9]. "Previous studies revealed that NO<sub>3</sub> accumulation in leafy vegetables was positively associated with inorganic N fertilizer rates, which are the controlling factor of NO<sub>3</sub> accumulation in vegetables" [5,10,11]. "Hence, there is a need to substitute the inorganic nutrient requirements with organic nutrient sources to enhance the production of greens with lower content of anti-nutritional factors" [6]. "Organic manures improves physical and biological activities of soil but they have comparatively low in nutrient content, so larger quantity is required for plant

growth. Among the organic manures vermicompost is easily prepared and much effective manure. By feeding earthworms with biomass and watching properly the food (biomass) of earthworm. The required quantities of vermicompost can be produce. Farmyard manure (FYM) is being used as major source of organic manure in field crops as it supplies all essential plant nutrients and increases activities of microbes in soil" [12,13-16]. "Limited availability of FYM is however an important constraint in its uses as source of nutrients. However, inorganic fertilizer is usually immediately and fast containing all necessary nutrients that are directly accessible for plants. But continuous use of inorganic fertilizers alone causes soil organic matter: degradation, soil acidity and environmental pollution. It is widely recognized that neither use of organic manures alone nor chemical fertilizers can achieve the sustainability of the yield under the modern intensive farming" [17]. "Therefore, it is essential to investigate the use of locally sourced organic materials which are environment friendly, cheap and probably an effective way of improving and sustaining the productivity of soils and crops" [18]. "The integrated use of organic and inorganic fertilizers not only increase mutual efficiency but also helps in the substitution of costly chemical fertilizers" [19]. "The concept of Integrated Nutrient Management (INM) is defined as adjustment or maintenance of soil fertility and supply of nutrient to plants up to an optimum level for sustaining the desired crop productivity through optimized utilization of all possible resources of plant nutrients in an integrated manner" [20]. "The integrated use of organic and inorganic fertilizers not only increase mutual efficiency but also helps in the substitution of

costly chemical fertilizers” [19]. Thus, the integration of organic and inorganic sources may improve and sustain crop yields without degrading soil fertility status. Therefore, this study was carried out to determine the effect of organic and inorganic fertilizers and their combinations on the grain yield of Palak.

## 2. MATERIALS AND METHODS

A research trial was taken up during *Rabi* season of 2021-2022 at polyhouse of Dr. B.R. Ambedkar university of social science at Mhow, Indore (M.P.). The experimental soil was clayey showed an estimated amount of about 0.52 per cent organic carbon, 224 kg ha<sup>-1</sup> available N, 12.2 kg ha<sup>-1</sup> available P and 309 kg ha<sup>-1</sup> available K. The experiment comprised of 6 treatments viz. T1 (75% RDF through inorganic fertilizers + 25% RDF through VC), T2 (75% RDF + 25% RDF through FYM), T3 (50% RDF + 50% RDF through VC), T4 (50% RDF + 50% RDF through FYM), T5 (100% RDF only inorganic), T6 (Control or without any fertilizers). The total number of plots were 24. The experimental site was well prepared, cultural practices include thinning, weeding, irrigation and manure application were followed for the healthy growth of crop.

Well-decomposed FYM and VC were used before 15 days of sowing. Inorganic fertilizers containing high amounts of NPK were applied as urea, single super phosphate (SSP), and muriate of potash (MOP), respectively. The fertilizers were applied through broad casting and mixed in the soil before sowing. Urea was applied in split doses to avoid N losses. Control plot was maintained without any inorganic and organic input. The spinach variety All-green was taken for present investigation. Palak growth and yield parameters were noted at 30, 45 and 60 days after sowing (DAS). Five plants taken for each plot. The fresh weight of the plant was noted using electrical balance for each treatment separately. For dry weight of plant was oven dried at 60°C for 24 hours then the dry weight of shoot was noted using electrical balance for each treatment separately. Then the average dry weight (g) was measured. Harvesting of green leaves was done weekly once or twice based on leaf yield and made into bunches. It has been calculated according to ratios in treatment for the required plot size. The plots were 1.2 × 1.0 m with 3 rows in each plot and a 50 cm space between plots. The initial dose, equivalent to one-third of the total N required, was applied as

basal dressing. The remaining two doses were administered at 15 days intervals thereafter.

The experiment data were analyzed using “Analysis of Variance Techniques” in Randomized Block Design (RBD). Data on growth, yield and quality parameters were collected and discussed below.

## 3. RESULTS AND DISCUSSION

### 3.1 Plant Height

The data presented in Table 1 indicated that all the treatments were found significant over control. Maximum plant height was obtained with treatment T5 (100% RDF through inorganics), which was significantly superior over the T1 (75% RDF + 25% RDF through VC), T2 (75% RDF + 25% RDF through FYM), T4 (50% RDF + 50% RDF through FYM) and at par with T3 (50% RDF + 50% RDF through VC). Highest plant height was shown in T5 about 20.16, 29.77 and 44.69 cm and shortest in control about 12.35, 19.44 and 22.44 cm at 30, 45 and 60 DAS, respectively. Plant height of T3 (19.62, 28.86 and 41.87 cm) was also found significant over T1 (17.42, 26.36 and 35.66 cm), T2 (17.13, 24.11 and 34.10 cm) and T4 (16.74, 20.75 and 27.88 cm) at 30, 45 and 60 DAS. The overall performance was T5>T3>T1>T2>T5>T6. “Increase in plant height in inorganic source may be due to inorganic fertilizer might have resulted in maximum nutrient uptake, leading to increased protein synthesis, cell division and cell enlargement which in turn are elaborated into protoplast and thereby protein is left available for cell wall formation materials, which is expressed morphologically in terms of increased plant height” [6]. “Maximum plant height in INM found due to organic manure and RDF increased the concentrations of nutrients in the root zone, which maintained active translocation of nutrients and increased plant growth. The integrated use of organic and inorganic fertilizers increase mutual efficiency” [19]. Increased plant height was also reported by [21] due to INM. Increase in plant height due to vermicompost and vermiwash has been reported by several workers [1] in spinach and [22] okra. VC have a much finer structure than other composts and organic manures and, hence, availing nutrients in a faster, readily available form for plant uptake [23] than FYM [24,25].

### 3.2 Leaf Width

The data presented in Table 1 indicated that leaf width of T5 (100% RDF) was significantly higher

than T1 (75% RDF + 25% RDF through VC), T2 (75% RDF + 25% RDF through FYM), T4 (50% RDF + 50% RDF through FYM) and statistically similar with T3 (50% RDF) + 50% RDF through VC). The maximum value of leaf width (4.83, 4.91 and 8.58 cm) was found in T5 and minimum (1.39, 1.32 and 4.17 cm) was in the control. T3 (4.35, 3.47 and 7.23 cm) also found significant over T1 (3.12, 3.85 and 6.00 cm), T2 (2.16, 3.12 and 5.70 cm), T4 (2.14, 2.61 and 4.87 cm) respectively at 30, 45 and 60 DAS. Significantly similar leaf width was obtained in the treatment T1, T2 and T3. Leaf width showed this trend T5>T3>T1>T2>T5>T6. "This might be due to the increased uptake of available major nutrients of the plant which results in the translocation of nutrients to the plant part". [26] This is in accordance with the findings of Jadhav et al., 2014 [26] who reported that "vermicompost influence plant growth directly via the supply of plant growth regulating substances (PGR) which results in the uptake of nutrients". Singh and Chauhan, 2009 [21] also stated that "vermicompost proved to be better not only than farmyard manure but also than chemical fertilizers in French bean".

### 3.3 Leaf Length

The data presented in Table 1 indicated that the maximum leaf length (9.48, 22.10 and 23.24 cm) was found in T5 (100% RDF) which was significantly higher than that of T1 (75% RDF + 25% RDF through VC), T2 (75% RDF + 25% RD through FYM), T4 (50% RDF + 50% RDF through FYM) and statistically similar with T3 (50% RDF + 50% RDF through VC). The lowest

value in T6 (control) was 4.16, 10.56 and 12.21 cm at respective growth stages. Leaf length treated T3 with were 8.10, 20.04 and 22.23 cm, respectively, which was significantly higher than that treated with T1 (6.73, 19.87 and 19.23 cm), T2 (5.04, 14.43 and 17.38 cm), T4 (4.86, 11.68 and 14.43 cm) at 30, 45 and 60 DAS. "Combined application of organic and inorganic nutrient sources improved synergism and synchronization between nutrient release and plant recovery thus resulted in better crop growth and yield" [27]. "The increase in leaf length due in VC treatment due to the increased uptake of nutrients might be the reason for increased plant spread in both directions". [28] This is found to be in accordance with findings of Kumar et al., 2013 [28] who stated that "the application of vermicompost in broccoli increased the nutrient uptake of the plant resulting in increased plant growth characters" [6]. "The lowest values were recorded in the FYM treatment, which means that plant N demands were worse satisfied by N released from the mineralized manure" [29].

### 3.4 Petiole Length

The data presented in Table 1 indicated that addition of T5 (100% RDF) significantly increased the petiole length (6.56, 9.27 and 10.89 cm) compared to T1 (75% RDF + 25% RDF through VC), T2 (75% RDF + 25% RDF through FYM), T4 (50% RDF + 50% RDF through FYM) and at par with T3 (50% RDF + 50% RDF through VC) at 30, 45 and 60 DAS. Minimum length found in the control with corresponding values were 3.19, 2.41 and 5.26

**Table 1. Effect of integrated nutrient management on growth parameters at 30, 60 and 90 DAS**

No.	Plant height (cm)			Leaf width(cm)			Leaf length (cm)			Petiole length (cm)		
	30	45	60	30	45	60	30	45	60	30	45	60
T1	17.42	26.36	35.66	3.12	3.85	5.47	6.73	19.87	19.23	4.25	6.42	7.41
T2	17.13	24.11	34.10	2.16	3.12	5.70	5.04	14.43	17.38	3.31	5.61	7.22
T3	19.62	28.86	41.87	4.35	3.47	7.23	8.10	20.04	22.23	5.99	8.44	9.17
T4	16.74	20.75	27.88	2.14	2.61	4.87	4.86	11.68	14.43	3.51	3.43	6.27
T5	20.16	29.77	44.69	4.83	4.91	8.58	9.48	22.10	23.24	6.56	9.27	10.89
T6	12.35	19.44	22.44	1.39	1.32	4.17	4.16	10.56	12.21	3.19	2.41	5.26
<b>Mean</b>	<b>17.24</b>	<b>24.88</b>	<b>34.44</b>	<b>3.00</b>	<b>3.21</b>	<b>11.20</b>	<b>6.39</b>	<b>16.45</b>	<b>18.12</b>	<b>4.47</b>	<b>5.93</b>	<b>7.70</b>
<b>SE</b>	<b>0.61</b>	<b>0.18</b>	<b>0.63</b>	<b>0.07</b>	<b>0.50</b>	<b>0.33</b>	<b>0.26</b>	<b>0.36</b>	<b>0.29</b>	<b>0.12</b>	<b>0.48</b>	<b>0.30</b>
<b>mean</b>												
<b>CD at 5%</b>	<b>1.84</b>	<b>0.53</b>	<b>1.88</b>	<b>0.22</b>	<b>1.50</b>	<b>1.01</b>	<b>0.80</b>	<b>1.08</b>	<b>0.89</b>	<b>0.36</b>	<b>1.44</b>	<b>0.92</b>

T1 – (75% RDF through Inorganics + 25% RDF through VC), T2 – (75% RDF + 25% RDF through FYM), T3 – (50% RDF + 50% RDF through VC), T4 – (50% RDF + 50% RDF through FYM), T5 – (100% RDF through inorganics), T6 – Control (No fertilizers)

cm respectively. Application of T3 (5.99, 8.44 and 9.17 cm) also significantly increased the petiole length over T1 (4.25, 6.42 and 7.41 cm), T2 (3.31, 5.61 and 7.22 cm), T4 (3.51, 3.43 and 6.27 cm) at the respective periods. However, the petiole length in treatments T2, T4, T5 and T6 were statistically similar to each other in all periods of recording at 30, 45 and 60 DAS. "Increased petiole length in inorganic fertilizers may be due to immediate availability of nutrients through inorganic fertilizers, along with organic manures ascribed to conducive physical environment that lead to higher nutrient absorption from the native as well as applied sources. This favored highest nutrient uptake and resulted in higher growth, whereas, reverse is true with organic manures. Highest value in VC attributed to release of higher amount of nutrients as well as growth stimulating substances excreted by earthworms in their casts" [30]. Lower value in FYM may be due to FYM are more resistant to decomposition and only about one third of the nitrogen is easily released due to this plant suffer deficiency during growing period. The remaining amount of nitrogen persisted in the soil for a long period [31,32-36].

### 3.5 No. of Leaf Plant<sup>-1</sup>

Table 2 shows that no. of leaf plant<sup>-1</sup> (12.58, 23.35 and 43.32 plant<sup>-1</sup>) found with treatment T5 (100% RDF) were significantly higher than those found with T1 (75% RDF + 25% RDF through VC), T2 (75% RDF + 25% RDF through FYM), T4 (50% RDF + 50% RDF through FYM) but similar to that with T3 (50% RDF + 50% RDF through VC) at 30, 45 and 60 DAS. No. of leaf plant<sup>-1</sup> did not differ significantly among the treatments T1, T2 and T4. Significantly similar no. of leaf plant<sup>-1</sup> (12.07, 21.57 and 37.82 plant<sup>-1</sup>) to the T5 was obtained in the treatment T3 (50% RDF + 50% RDF through VC) at 30, 45 and 60 DAS. However, application of T3 also produced significantly higher no. of leaf plant<sup>-1</sup> than that with T1, T2 and T4. "The increased no. of leaf plant<sup>-1</sup> might be due to added organics in integrated nutrient management which would have improved the physical, chemical and biological properties of soil which also helped the plant to better nutrient absorption and utilization by the plant. This might be due to the increased uptake of available major nutrients of the plant which results in the translocation of nutrients to the plant part" [6]. The results agreed with the research findings by many workers [37,38] in spinach. Maximum value in VC might be due to application of VC supply most nutrients in the

available form such as nitrates, phosphates, exchangeable calcium and soluble potassium and also plant growth regulating substances, necessary for plant growth parameters. This result is in agreement with the many workers in radish [26], in tomato [39] in beetroot [40], in amaranthus [41], they stated that the application of vermicompost increases the plant growth promoting substances which results in the increase in number of leaves plant<sup>-1</sup>.

### 3.6 Fresh Weight

Data presented in Table 2 indicated that significantly higher fresh weight of leaves (17.97, 37.27 and 78.36 g, respectively) was recorded with the application of T5 (100% RDF) compared to with T1 (75%RDF + 25% RDF through VC), T2 (75% RDF + 25% RDF through FYM), T4 (50% RDF + 50% RDF through FYM) and it was at par with the application of T3- 50% RDF + 50% RDF through VC (15.18, 35.00 and 70.37 g, respectively) at 30, 45 and 60 DAS. Application of T3- 50% RDF + 50% RDN through VC was also differed significantly from T1 (14.45, 32.70 and 62.99 g), T2 (12.86, 29.73 and 53.02 g) and T4 (9.91, 28.73 and 47.01 g). The lowest fresh weight being in the control (9.49, 21.38 and 42.18 g). T1, T2 and T4 all being found at par among themselves. Growth responses were due to the ability of humic acids present in vermicompost to act as plant growth regulators or because the humates may have absorbed hormonal plant growth regulators which increase fresh weight of palak [42,43-46]. So VC and chemical fertilizers proved to be better than FYM and chemical fertilizers [47].

### 3.7 Dry Weight

Table 2 showed that dry weight all treatment were found significant over control (2.37, 5.35 and 10.67 g). The highest dry weight of palak leaf (4.49, 9.32 and 19.59 g, respectively) was under T5 (100% RDF) treatment followed by T3- 50% RDF + 50% RDF through VC (3.79, 8.75 and 17.59 g, respectively) both being at par and significantly higher than T1 (75% RDF+ 25% RDF through VC), T2 (75% RDF+ 25% RDF through FYM), T4 (50% RDF + 50% RDN through FYM) at 30, 45 and 60

DAS. Dry weight of T1 (3.61, 7.68 and 15.64 g), T2 (3.21, 7.43 and 13.25 g) and T4 (2.48, 7.18 and 11.75 g) remained at par among themselves. Du et al., [19] reported that "the co application of NPK with organic manure increased the size of

**Table 2. Effect of integrated nutrient management on growth parameters and yield at 30, 60 and 90 DAS**

No.	No. of leaf/ plant			Fresh weight (g)			Dry weight (g)			Yield (q ha <sup>-1</sup> )		
	30	45	60	30	45	60	30	45	60	30	45	60
T1	10.47	18.70	34.47	14.45	32.10	62.99	3.61	7.68	15.74	92.78	91.25	90.42
T2	9.13	17.35	25.80	12.86	29.73	53.02	3.21	7.43	13.25	80.35	80.12	80.15
<b>T3</b>	12.07	21.57	37.82	15.18	35.00	70.37	3.79	8.75	17.59	94.84	94.00	94.56
T4	8.77	16.31	22.51	9.91	28.73	47.01	2.48	7.18	11.75	74.38	75.44	74.42
<b>T5</b>	12.58	23.35	43.32	17.97	37.27	78.36	4.49	9.32	19.59	99.87	95.48	95.48
T6	8.41	16.32	20.47	9.49	21.38	42.18	2.37	5.35	10.67	70.7	70.12	70.15
<b>Mean</b>	<b>10.24</b>	<b>18.93</b>	<b>30.73</b>	<b>13.31</b>	<b>4.55</b>	<b>58.99</b>	<b>3.32</b>	<b>7.67</b>	<b>14.76</b>	<b>84.48</b>	<b>84.40</b>	<b>80.53</b>
<b>SE mean</b>	<b>0.41</b>	<b>0.35</b>	<b>1.22</b>	<b>0.43</b>	<b>0.70</b>	<b>4.76</b>	<b>0.11</b>	<b>0.17</b>	<b>0.40</b>	<b>0.32</b>	<b>9.77</b>	<b>0.17</b>
<b>CD at 5%</b>	<b>1.24</b>	<b>1.06</b>	<b>3.69</b>	<b>1.29</b>	<b>2.10</b>	<b>14.36</b>	<b>0.32</b>	<b>0.52</b>	<b>1.22</b>	<b>0.45</b>	<b>29.47</b>	<b>0.52</b>

T1 – (75% RDF through Inorganics + 25% RDF through VC), T2 – (75% RDF + 25% RDF through FYM), T3 – (50% RDF + 50% RDF through VC), T4 – (50% RDF + 50% RDF through FYM), T5 – (100% RDF through inorganics), T6 – Control (No fertilizers)

the root which was caused mainly by greater root proliferation, branching and dry-matter accumulation". "This effect might be due to increase in dry matter production during the growth stages due to availability of sufficient nutrient in soil through out growing period due to application of organic manure" [48]. "Lower dry weight in FYM due to higher C:N ratio, which causes N to be immobilized Srinivasarao 2014. Enhancement of growth in VC might be due to greater the nutrient availability, and increase in beneficial enzymatic activities, increased population of beneficial microorganisms or the presence of biologically active plant growth influencing substances such as plant growth regulators or plant hormones" (Arancon et al., 2006) [49-53].

### 3.8 Yield

Data given in Table 2 showed that highest yield (99.87, 95.48 and 95.48 g) was recorded in T5 (100% RDF) treatment which was significantly higher than the yield of T1 (75% RDF + 25% RDF through VC), T2 (75% RDF + 25% RDF through FYM), T4 (50% RDF + 50% RDF through FYM) and at par with T3 (50% RDF + 50% RDF through VC) at 30, 45 and 60 DAS. However yields of T3 was significantly greater (94.84, 94.00 and 88.77 q ha<sup>-1</sup>) than those under the T1 (90.73, 91.25 and 80.31 q ha<sup>-1</sup>), T2 (80.35, 80.12 and 79.47 q ha<sup>-1</sup>) and T4 (74.38, 75.44 and 74.32 q ha<sup>-1</sup>) at 30, 45 and 60 DAS. Lowest yield found in control (70.7, 70.12 and 70.15 q ha<sup>-1</sup>) at respective growth stages. These results supported by Joshi et al. (2013) [40] in his study who reported that most of the growth, yield and quality parameters had greatest values in treatment with RDF. "Maximum yield found in inorganic fertilizers may be due to the fact that inorganic fertilizers releases nutrients for the plants instantly and in readily available forms for the plants during its growth, development and reproductive phases where the nutrient demand is at its peak" [54]. "Increased yield in INM due to immediate availability of nutrients through inorganic fertilizers, along with organic manures ascribed to conducive physical environment that lead to higher nutrient absorption from the native as well as applied sources. This favored highest nutrient uptake and ultimately resulted in higher yield, whereas, reverse is true with organic manures" [28]. "Higher value of yield in VC may be due to VC supplied nutrients to plant root in balanced amount and stimulate growth, increased organic matter content in soil including the humic substance that affected nutrients

accumulation and promoted root growth which led to better growth of plants" [55]. "Lower yield in FYM treatment due to slow-acting bulky organic manures like compost and farm yard manure are hard to decompose (because of wider C: N ratio) and making nitrogen available at later stages thus plant suffer for nutrient at early stage which ultimately reduce yield" [56]. "Vermicompost supplemented with chemical fertilizers gave best results compare to alone VC and combination of FYM with chemical fertilizers" [39]. Similar results also observed by [10,25,54] also reported higher spinach leaf yield with integrated nutrient management practices.

### 4. CONCLUSION

Based on the results it was concluded that application of different combination of nutrient sources was found to improve the growth and yield of spinach. Integrated application of 50 % RDF + 50 % RDF through VC was found optimum for better growth and higher yield of spinach.

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### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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