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Effect of integrated nutrient management on leaf nutrient status, yield and quality of spinach (*Beta vulgaris* L.) var. Pusa Jyoti

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Abstract
The present investigation entitled "Effect of integrated nutrient management on leaf nutrient status, yield and quality of spinach (*Beta vulgaris* L.) var. Pusa Jyoti" was carried out during *kharif* 2016 – 17 (first year), 2017 – 18 (second year) and pooled at the Experimental field, Krishi Vigyan Kendra, RVSKVV, Datia (M.P.) with 16 treatment combinations of three levels of inorganic fertilizers i.e. 50% RDF (75:40:50 kg NPK ha^{-1}), 75% RDF (112.5:60:75 kg NPK ha^{-1}) and 100% RDF control (150:80:100 kg NPK ha^{-1}), three organic manure i.e. 20 t FYM ha^{-1}, 10 t vermicompost (VC) ha^{-1} and 7.5 t poultry manure (PM) ha^{-1} and two bio-fertilizers viz,. 5 kg Azotobacter (Azo) ha^{-1} and 5 kg PSB ha^{-1}. Experiments were laid out in Randomized Complete Block Design with three replications. Results revealed that the application of 75% RDF + 10 t Vermicompost ha^{-1} + 5 kg PSB ha^{-1} + 5 kg *Azotobacter* ha^{-1} (T_8) was recorded significantly maximum leaf nitrogen (51.30, 52.30 and 51.80 g kg^{-1}), phosphorus (7.30, 8.30 and 7.80 g kg^{-1}), potash (57.30, 58.30 and 57.80 g kg^{-1}), vitamin 'C' (49.6, 51.0 and 50.30 mg 100 g^{-1}), chlorophyll index (140.20, 141.20 and 140.70 mg 100 g^{-1}) and leaves yield $hectare^{-1}$ (252.27, 254.87 and 253.57 q ha^{-1}) at first year, second year and pooled, respectively as compared to control.

Keywords: vermicompost, poultry manure, *Azotobacter,* PSB, vitamin 'C' and chlorophyll index

Introduction

Spinach Beet or Palak (*Beta vulgaris* var. bengalensis) also known as Indian Spinach, Spinach beet, Garden Beet, Palong palang, Sag, Teegabatchali, Busabyeley, Dumpsbucchale and Pasalai can be grown in tropical and sub tropical regions. Leafy vegetables play important role in the diets of an individual by providing essential nutrients necessary for proper upkeep is well recognized. It is very rich in minerals and vitamins "A" and "C" and also contents appreciable amounts of protein, calcium, iron and roughages. Its high productivity of large green leaves with succulent stem almost throughout the year make it highly remunerative to the vegetable growers. Bio-fertilizers being essential components of organic farming play a vital role in maintaining long term soil fertility and sustainability by fixing atmospheric nitrogen, mobilizing fixed macro and micro nutrients or convert insoluble phosphorous in the soil into forms available to plants, by increasing their efficiency and availability. Biofertilzers are less expensive, eco-friendly and sustainable likely to assume greater significance as a compliment or supplement to inorganic fertilizers. Azotobacter is an aerobic, free-living gram negative bacterium which fixes nitrogen from the atmosphere. The phosphate solubilising bacteria are increases in the availability of phosphorus in the soil through secretion of phosphatase enzyme which leads to transfer organic phosphorus to available form. Consequently, it increases phosphorus absorption and accumulation in plant tissues.

Nitrogen fertilizers increase the nitrate content of the crop tissues. Chlorophylls are most important for photochemical process and are virtually essential for oxygen conversion of light energy to stored chemical energy. The use of organic manures and biofertilzers can reduce the application of chemical fertilizers to a great extent. It is possible when to reduce the use of the chemical fertilizers which will be beneficial for formers to reduce their production costs and the soil will be high in fertility and productivity. The present studies was undertaken to develop a suitable package in combination in organic, inorganic and biofertilizers in sustainable crop in spinach beet.

Materials and Methods

The present investigation entitled "Effect of integrated nutrient management on leaf nutrient status, yield and quality of spinach (*Beta vulgaris* L.) var. Pusa Jyoti" was carried out during *rabi* 2016 – 17 (first year), 2017 – 18 (second year) and pooled at the Experimental field, Krishi Vigyan Kendra, Datia (M.P.) The experimental material for the present investigation was comprised of 16 treatments combinations of three levels of inorganic fertilizers i.e. 50% RDF (75:40:50 kg NPK ha^{-1}), 75% RDF (112.5:60:75 kg NPK ha^{-1}) and 100% RDF control (150:80:100 kg NPK ha^{-1}), three organic manure i.e. 20 t FYM ha^{-1}, 10 t vermicompost (VC) ha^{-1} and 7.5 t poultry manure (PM) ha^{-1} and two bio-fertilizers viz,. 5 kg *Azotobacter* (*Azo*) ha^{-1} and 5 kg PSB ha^{-1}. Experiments were laid out in Randomized Complete Block Design as suggested by Panse and Sukhatme (1985) [7] with three replications. Observations were recorded on the basis of five random competitive plants selected from each treatment separately for leaf nutrient status, yield and quality parameters were evaluated as per standard procedure. There are some minor differences in data of both the year due to some environmental factors such as temperature, rainfall, humidity and evaporation etc. the experimental plants were regularly observed and the data were recorded on leaf nitrogen, phosphorus, potash, vitamin 'C', chlorophyll index and leaves yield per hectare.

Results and Discussion

It is obvious from data (Table 1 and Fig 1) that the significantly maximum 51.30, 52.30 and 51.80 g kg^{-1} leaf nitrogen was content under the treatment T_8 (75% RDF + 10 t Vermicompost ha^{-1} + 5 kg PSB ha^{-1} + 5 kg *Azotobacter* ha^{-1}), followed by T_7 (75%RDF + 10 t Vermicompost ha^{-1} + 5 kg *Azotobacter* ha^{-1}) (48.70, 50.00 and 49.35 g kg^{-1}) and T_{12} (75% RDF + 7.5 t Poultry Manure ha^{-1} + 5 kg PSB ha^{-1} + 5 kg *Azotobacter* ha^{-1}) (46.10, 47.60 and 46.85 g kg^{-1}) at first year, second year and pooled, respectively and which were at par with each other except T_{12} in pooled. However, it was recorded lowest 11.70, 13.0 and 12.35 g kg^{-1} in treatment T_1 (75% RDF + 20 t FYM ha^{-1}) at first year, second year and pooled, respectively. The increment of nitrogen content in leaf could be ascribed to additive effect of both sources of nutrient (organic and inorganic) associated with microbial population through inoculation of *Azotobacter* helping in mobilizing N fixation in to soil solution in soluble from, there by higher release of all nutrient forms, which resulted in very efficient uptake and inefficient reduction systems in spinach. Results of the present investigation was also in confirmatory with the findings of Peyvast *et al.* (2008), Revathi *et al.* (2012) [11], Ali *et al.* (2013), Qureshi *et al.* (2014) [10], Shahein *et al.* (2014) [12], Muhmood *et al.* (2014) [6], El-Aila *et al.* (2015) and Parbhankar and Mogle (2017).

Significantly maximum 7.30, 8.30 and 7.80 g kg^{-1} leaf phosphorus was content under the treatment T_8 (75% RDF + 10 t Vermicompost ha^{-1} + 5 kg PSB ha^{-1} + 5 kg *Azotobacter* ha^{-1}) followed by T_7 (75%RDF + 10 t Vermicompost ha^{-1} + 5 kg *Azotobacter* ha^{-1}) (7.10, 8.10 and 7.60g kg^{-1}), T_{12} (75% RDF + 7.5 t Poultry Manure ha^{-1} + 5 kg PSB ha^{-1} + 5 kg *Azotobacter* ha^{-1}) (6.80, 7.80 and 7.30g kg^{-1}) and T_{11} (75% RDF + 7.5 t Poultry Manure ha^{-1} + 5 kg *Azotobacter* ha^{-1}) (6.50, 7.50 and 7.0 g kg^{-1}) at first year, second year and pooled, respectively and which were at par with each other except T_{11} in pooled. Therefore, it was recorded lowest 4.11, 5.20 and 4.66 g kg^{-1} in treatment T_1 (75% RDF + 20 t FYM ha^{-1}) at first year, second year and pooled, respectively (Table 1 and Fig 2). The increment of phosphorus content in leaf could be ascribed to additive effect of both sources of nutrient (organic and inorganic) associated with microbial population through inoculation of PSB helping in mobilizing P fixation in to soil solution in soluble from, there by higher release of nutrient forms, which resulted in very efficient uptake of phosphorus by spinach. Similar results have also been reported by Peyvast *et al.* (2008), Revathi *et al.* (2012) [11], Ali *et al.* (2013), Shahein *et al.* (2014) [12], Muhmood *et al.* (2014) [6] and El-Aila *et al.* (2015).

Significantly maximum 57.30, 58.30 and 57.80 g kg^{-1} leaf potash was content under the treatment T_8 (75% RDF + 10 t Vermicompost ha^{-1} + 5 kg PSB ha^{-1} + 5 kg *Azotobacter* ha^{-1}) followed by T_7 (75%RDF + 10 t Vermicompost ha^{-1} + 5 kg *Azotobacter* ha^{-1}) (54.10, 55.50 and 54.80 g kg^{-1}), at first, second year and pooled, respectively and which were at par with each other at first and second year. However, it was recorded lowest 13.85, 14.85 and 14.35 g kg^{-1} in treatment T_1 (75% RDF + 20 t FYM ha^{-1}) at first, second year and pooled, respectively (Table1 and Fig 3). The increased of potash content in leaf could be ascribed to additive effect of both sources of nutrient (organic and inorganic) associated with microbial population. Which could be resulted in positive effect on absorption of K by plant with slow release fertilizers. The present results are therefore in conformity with the results of Peyvast *et al.* (2008), Revathi *et al.* (2012) [11], Ali *et al.* (2013), Shahein *et al.* (2014) [12], Muhmood *et al.* (2014) [6] and El-Aila *et al.* (2015).

It is obvious from data (Table 2 and Fig 4) that the significantly maximum 49.6, 51.0 and 50.30 mg 100 g^{-1} vitamin 'C' was noted under the treatment T_8 (75% RDF + 10 t Vermicompost ha^{-1} + 5 kg PSB ha^{-1} + 5 kg *Azotobacter* ha^{-1}) followed by T_7 (75%RDF + 10 t Vermicompost ha^{-1} + 5 kg *Azotobacter* ha^{-1}) (47.80, 49.0 and 48.40 mg 100 g^{-1}) and T_{12} (75% RDF + 7.5 t Poultry Manure ha^{-1} + 5 kg PSB ha^{-1} + 5 kg *Azotobacter* ha^{-1}) (46.20, 47.50 and 46.85 mg 100 g^{-1}) at first, second year and pooled, respectively and which were at par with each other except T_{12} in pooled. However, it was recorded lowest 28.40, 29.30 and 28.85 mg 100 g^{-1} in treatment T_1 (75% RDF + 20 t FYM ha^{-1}) at first, second year and pooled, respectively. This may be due to the fact that the greater amounts of K present in vermicompost and higher level of carbohydrates fovoured greater synthesis of ascorbic acid hence vitamin C production in tightly linked with carbohydrates metabolism. The present results are therefore in conformity with the results of Revathi *et al.* (2012) [11], Bharad *et al.* (2013), Qureshi *et al.* (2014) [10] and Abdollahi and Jafarpour (2015).

Significantly maximum 140.20, 141.20 and 140.70 mg 100 g^{-1} chlorophyll index was estimated under the treatment T_8 (75% RDF + 10 t Vermicompost ha^{-1} + 5 kg PSB ha^{-1} + 5 kg *Azotobacter* ha^{-1}) followed by T_7 (75%RDF + 10 t Vermicompost ha^{-1} + 5 kg *Azotobacter* ha^{-1}) (138.70, 140.0 and 139.35 mg 100 g^{-1}), T_{12} (75% RDF + 7.5 t Poultry Manure ha^{-1} + 5 kg PSB ha^{-1} + 5 kg *Azotobacter* ha^{-1}) (137.10, 138.10 and 137.60 mg 100 g^{-1}), T_{11} (75% RDF + 7.5 t Poultry Manure ha^{-1} + 5 kg *Azotobacter* ha^{-1}) (135.60, 137.0 and 136.30 mg 100 g^{-1}), T_6 (75% RDF + 10 t Vermicompost ha^{-1} + 5 kg PSB ha^{-1}) (134.10, 135.10 and 134.60 mg 100 g^{-1}) and T_{10} (75% RDF + 7.5 t Poultry Manure ha^{-1} + 5 kg PSB ha^{-1}) (133.70, 135.0 and 134.35 mg 100 g^{-1}) at first, second year and pooled, respectively and which were at par with each other except T_{11}, T_6 and T_{10} in pooled. However, it was recorded lowest 121.30, 122.50 and 121.90 mg 100 g^{-1} in treatment T_1 (75% RDF + 20 t FYM ha^{-1}) at first, second year and pooled, respectively (Table 2 and Fig 5). This may be due to the fact that the greater amount of nitrogen present in this treatment and nitrogen is a major constituent for formation of chlorophyll molecule. Similar results have also been reported by Ali *et al.* (2013), Bharad *et al.* (2013), Shahein *et al.* (2014) [12], Abdollahi and Jafarpour (2015), Jafarpour and Rahimzadeh (2015) and Parbhankar and Mogle (2017).

Significantly maximum 252.27, 254.87 and 253.57 q ha^{-1} leaves yield was noted under the treatment T_8 (75% RDF + 10 t Vermicompost ha^{-1} + 5 kg PSB ha^{-1} + 5 kg *Azotobacter* ha^{-1}) followed by T_7 (75%RDF + 10 t Vermicompost ha^{-1} + 5 kg *Azotobacter* ha^{-1}) (247.64, 250.61 and 249.13 q ha^{-1}) and T_{12} (75% RDF + 7.5 t Poultry Manure ha^{-1} + 5kgPSB ha^{-1} + 5 kg *Azotobacter* ha^{-1}) (241.37, 242.48 and 241.93 q ha^{-1}) at first year, second year and pooled, respectively and which were at par with each other. While, it was recorded lowest 172.39, 173.04 and 172.71 q ha^{-1} in treatment T_1 (75% RDF + 20 t FYM ha^{-1}) at first, second year and pooled, respectively (Table 2 and Fig 6). The increment of yield could be ascribed to additive effect of both sources of nutrient (organic and inorganic) associated with microbial population through inoculation of *Azotobacter* and PSB (biofertilizers) helping in mobilizing P and N fixation in to soil solution in soluble from, there by higher release of nutrient forms, this in turn reflected in promoted growth and proliferation of root, increased the rate of absorption, increased photosynthesis productivity and better source-sink relationship. Results of the present investigation was also in confirmatory with the findings of Revathi *et al.* (2012) [11], Ali *et al.* (2013), Bharad *et al.* (2013), Qureshi *et al.* (2014) [10], Shahein *et al.* (2014) [12], Muhmood *et al.* (2014) [6] and Jafarpour and Rahimzadeh (2015).

Table 1: Effect of integrated nutrient management on Leaf nutrient (NPK) status in first, second year and pooled of spinach

Treat. Symb.	Treatment	Leaf nutrient (N) status (g kg^{-1} FW) at			Leaf nutrient (P) status (g kg^{-1} FW) at			Leaf nutrient (K) status (g kg^{-1} FW) at		
		1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
T_1	75% RDF + 20 t FYM ha^{-1}	11.70	13.00	12.35	4.11	5.20	4.66	13.85	14.85	14.35
T_2	75%RDF+20 t FYM ha^{-1} +5kgPSB ha^{-1}	14.10	15.10	14.60	4.28	5.48	4.88	16.71	17.71	17.21
T_3	75%RDF+20 t FYM ha^{-1}+5kg *Azo.* ha^{-1}	17.30	18.80	18.05	4.58	5.88	5.23	19.65	20.85	20.25
T_4	75%RDF+20tFYM ha^{-1}+5kgPSB ha^{-1}+5kg *Azo.* ha^{-1}	19.60	21.00	20.30	4.87	6.10	5.49	22.43	23.66	23.05
T_5	75% RDF + 10 t Vermicompost ha^{-1}	35.60	37.00	36.30	5.85	6.85	6.35	40.10	41.60	40.85
T_6	75% RDF+10 t VC ha^{-1}+5kgPSBha^{-1}	40.90	42.00	41.45	6.20	7.20	6.70	45.40	46.40	45.90
T_7	75%RDF+10tVC ha^{-1} +5kg *Azo.*ha^{-1}	48.70	50.00	49.35	7.10	8.10	7.60	54.10	55.50	54.80
T_8	75% RDF+10tVC ha^{-1} + 5 kg PSB ha^{-1} + 5 kg *Azo.* ha^{-1}	51.30	52.30	51.80	7.30	8.30	7.80	57.30	58.30	57.80
T_9	75% RDF + 7.5 t Poultry Manure ha^{-1}	32.80	34.00	33.40	5.73	6.84	6.29	37.30	38.80	38.05
T_{10}	75%RDF+7.5t PM ha^{-1}+ 5kg PSB ha^{-1}	38.20	39.20	38.70	6.05	7.05	6.55	42.90	43.90	43.40
T_{11}	75% RDF+7.5 tPM ha^{-1}+5 kg *Azo.* ha^{-1}	43.50	45.00	44.25	6.50	7.50	7.00	47.80	48.80	48.30
T_{12}	75% RDF + 7.5 t PM ha^{-1} +5kg PSB ha^{-1} + 5 kg *Azo.* ha^{-1}	46.10	47.60	46.85	6.80	7.80	7.30	50.20	51.70	50.95
T_{13}	50% RDF + 20 t FYM ha^{-1} + 5 kg *Azo.* ha^{-1} + 5kgPSB ha^{-1}	22.10	23.70	22.90	5.00	6.16	5.58	25.15	26.30	25.73
T_{14}	50% RDF + 10 t VC ha^{-1} + 5 kg *Azo.* ha^{-1} + 5kgPSB ha^{-1}	27.40	28.40	27.90	5.33	6.53	5.93	31.80	33.00	32.40
T_{15}	50% RDF + 7.5 t PM ha^{-1} + 5 kg *Azo.* ha^{-1} + 5kgPSB ha^{-1}	24.70	26.00	25.35	5.15	6.20	5.68	28.05	29.45	28.75
T_{16}	Control (100 %RDF150:80:100 kg NPK ha^{-1})	30.20	31.20	30.70	5.54	6.73	6.14	34.50	36.33	35.42
	SEm±	2.65	2.65	1.53	0.48	0.31	0.23	2.00	1.33	0.98
	C.D. at 5% level	7.66	7.65	4.31	1.38	0.90	0.66	5.78	3.84	2.76

Table 2: Effect of integrated nutrient management on vitamin "C" content, chlorophyll index and leaves yield q ha-1 in first, second year and pooled of spinach

Treat. Symb	Treatment	Vitamin C content (mg $100g^{-1}$) at			Chlorophyll index at			Leaves yield $hectare^{-1}$ (q) at		
		1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
T_1	75% RDF + 20 t FYM ha^{-1}	28.40	29.30	28.85	121.30	122.50	121.90	172.39	173.04	172.71
T_2	75%RDF+20 t FYM ha^{-1} +5kg PSB ha^{-1}	29.70	30.30	30.00	122.70	125.00	123.85	175.64	177.76	176.70
T_3	75%RDF+20 t FYM ha^{-1}+5kg *Azo.* ha^{-1}	30.50	31.20	30.85	124.00	125.33	124.67	180.41	181.16	180.79
T_4	75%RDF+20tFYM ha^{-1}+5kg PSB ha^{-1}+5kg *Azo.* ha^{-1}	32.10	33.00	32.55	125.40	126.50	125.95	184.39	186.62	185.51
T_5	75% RDF + 10 t VC ha^{-1}	40.10	41.10	40.60	132.30	133.60	132.95	215.72	216.34	216.03
T_6	75% RDF+10 t VC ha^{-1}+5kg PSBha^{-1}	43.30	44.10	43.70	134.10	135.10	134.60	228.40	231.52	229.96
T_7	75%RDF+10tVC +5kg *Azo.* ha^{-1}	47.80	49.00	48.40	138.70	140.00	139.35	247.64	250.61	249.13
T_8	75% RDF+10 t VC ha^{-1} + 5 kg PSB ha^{-1} + 5 kg *Azo.* ha^{-1}	49.60	51.00	50.30	140.20	141.20	140.70	252.27	254.87	253.57
T_9	75% RDF + 7.5 t PM ha^{-1}	38.60	39.30	38.95	131.80	133.00	132.40	211.50	216.45	213.98
T_{10}	75%RDF+7.5t PM ha^{-1}+ 5kg PSB ha^{-1}	41.70	42.60	42.15	133.70	135.00	134.35	221.31	223.85	222.58
T_{11}	75% RDF+7.5 tPM ha^{-1}+5 kg *Azo.* ha^{-1}	44.70	46.00	45.35	135.60	137.00	136.30	234.50	236.37	235.44
T_{12}	75% RDF + 7.5 t PM ha^{-1} +5kg PSBha^{-1} + 5 kg *Azo.* ha^{-1}	46.20	47.50	46.85	137.10	138.10	137.60	241.37	242.48	241.93
T_{13}	50% RDF + 20 t FYM ha^{-1} + 5 kg *Azo.* ha^{-1} + 5kgPSB ha^{-1}	33.40	34.20	33.80	126.70	128.00	127.35	189.57	192.09	190.83
T_{14}	50% RDF + 10 t VC ha^{-1} + 5 kg *Azo.* ha^{-1} + 5kgPSB ha^{-1}	35.50	36.20	35.85	129.30	130.50	129.90	201.34	204.60	202.97
T_{15}	50% RDF + 7.5 t PM ha^{-1} + 5 kg *Azo.* ha^{-1} + 5kgPSB ha^{-1}	34.80	35.50	35.15	128.00	129.00	128.50	194.37	197.29	195.83
T_{16}	Control (100 %RDF150:80:100 kg NPK ha^{-1})	37.00	38.00	37.50	130.50	132.00	131.25	204.61	208.21	206.41
	SEm±	2.35	1.89	1.23	2.57	2.79	1.55	6.92	8.41	4.46
	C.D. at 5% level	6.79	5.45	3.46	7.42	8.06	4.36	19.99	24.30	12.54

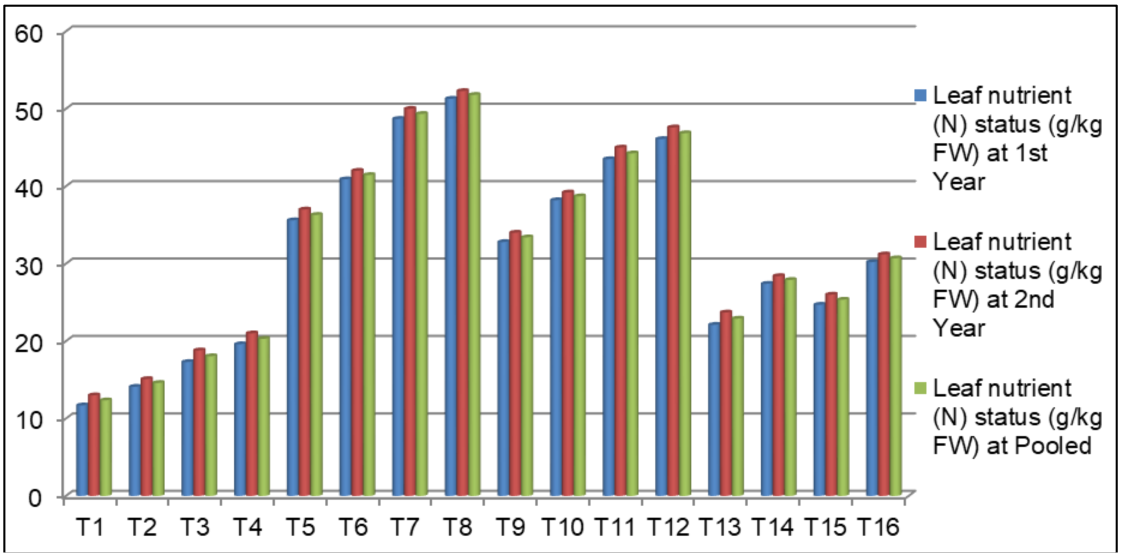

Fig 1: Effect of integrated nutrient management on leaf nutrient (N) status (g kg-1 FW) of spinach in first, second year and pooled

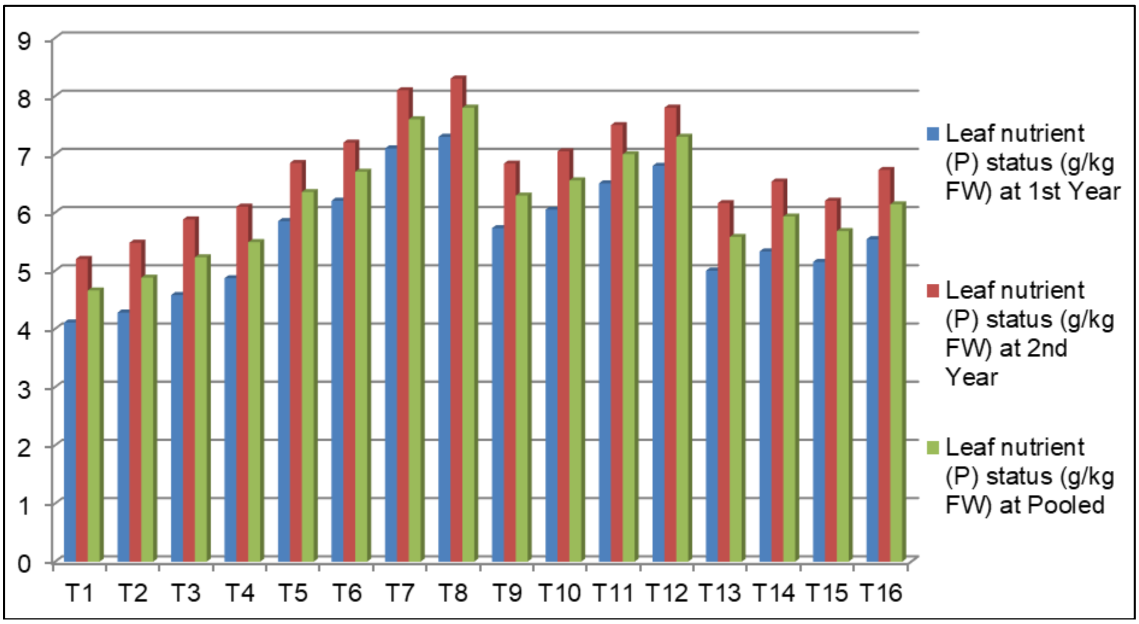

Fig 2: Effect of integrated nutrient management on leaf nutrient (P) status (g kg^{-1} FW) of spinach in first, second year and pooled

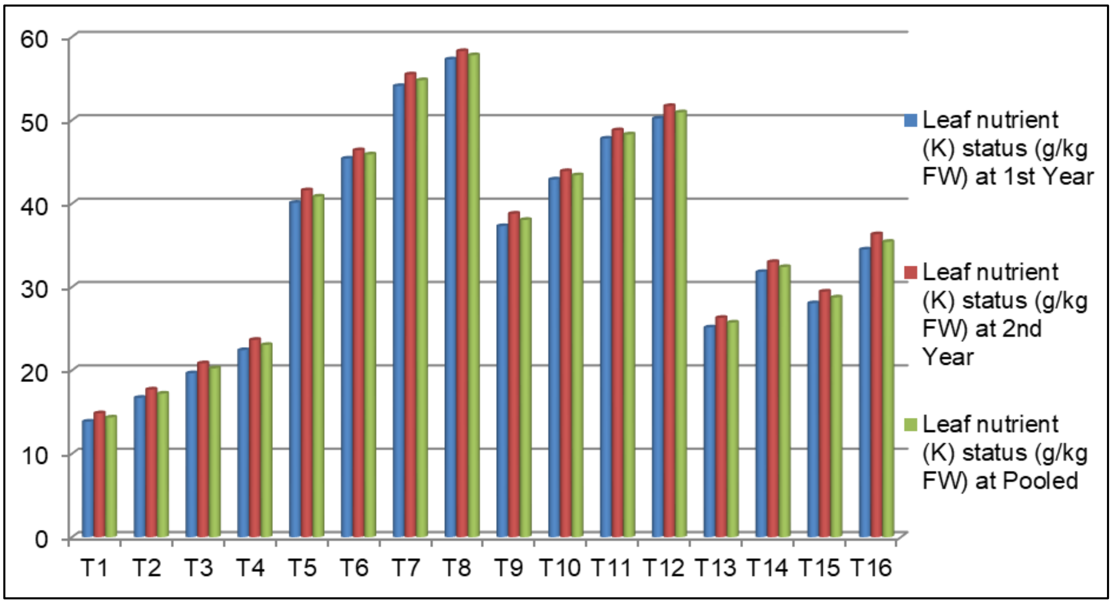

Fig 3: Effect of integrated nutrient management on leaf nutrient (K) status (g kg^{-1} FW) of spinach in first, second year and pooled

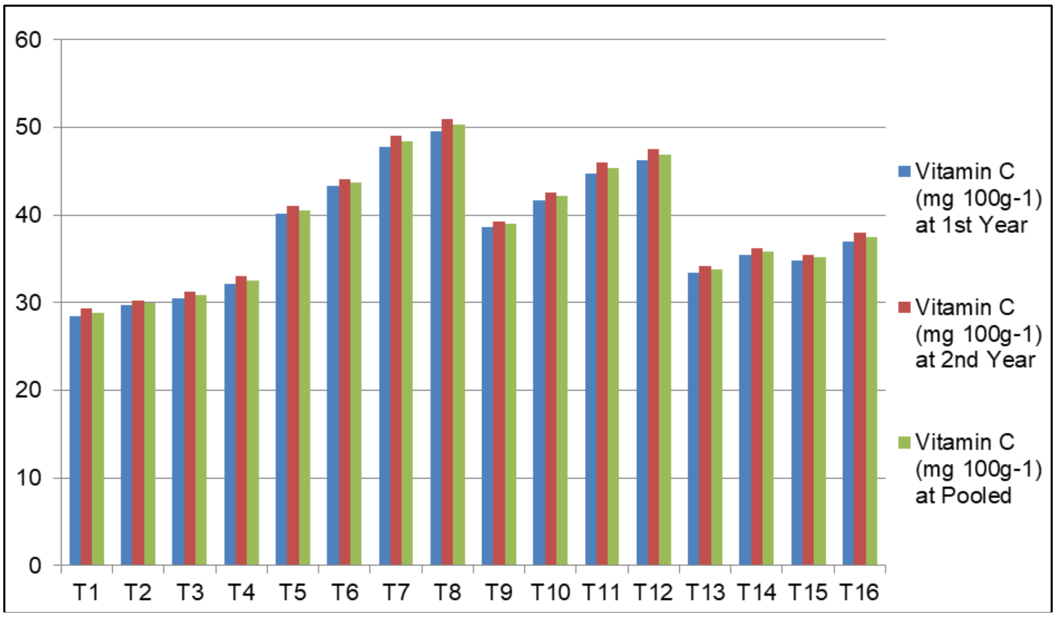

Fig 4: Effect of integrated nutrient management on vitamin C content (mg $100g^{-1}$) of spinach in first, second year and pooled

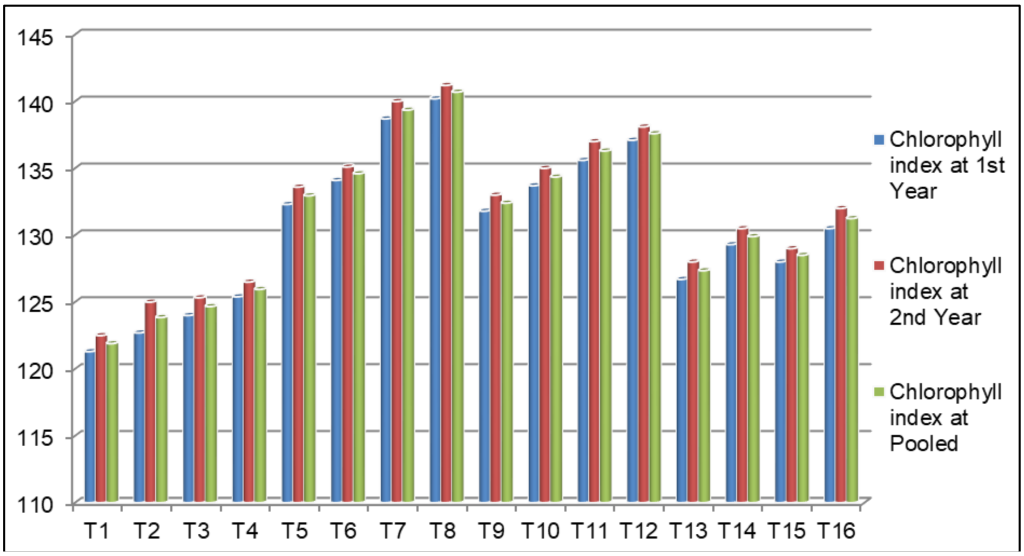

Fig 5: Effect of integrated nutrient management on chlorophyll index of spinach in first, second year and pooled

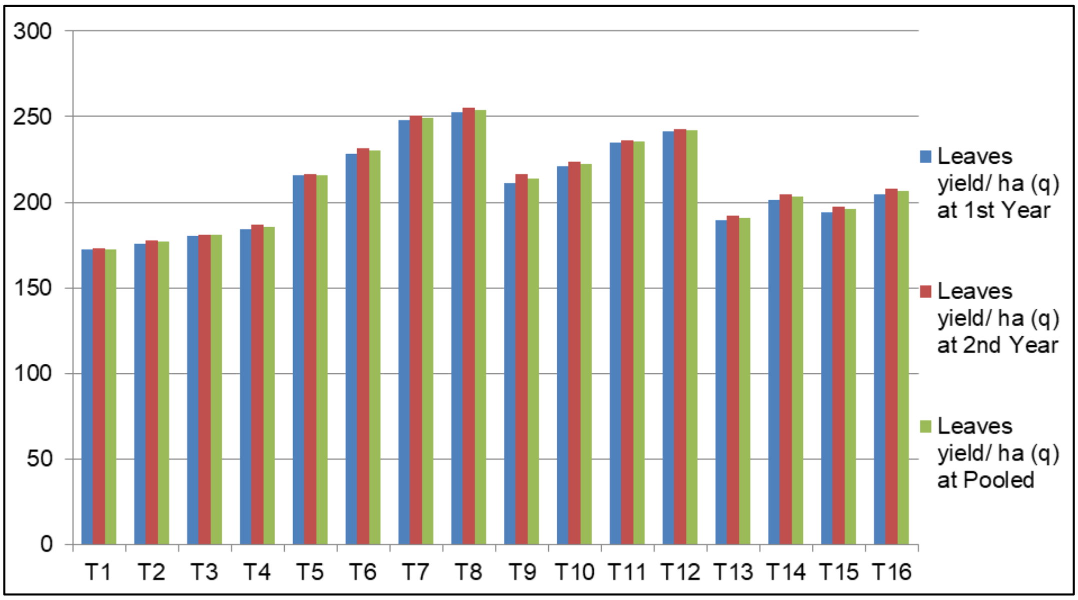

Fig 6: Effect of integrated nutrient management on leaves yield $hectare^{-1}$ (q) of spinach in first, second year and pooled

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