Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(3): 938-942
Received: 13-03-2019
Accepted: 15-04-2019

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Quality improvement of palak (*Beta vulgaris* var. *bengalensis* Hort.) through organic manures

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Abstract
Field experiments were conducted in the farmer's field located at Sandayagoundampalayam in Thondammutur block of Coimbatore district during October 2015 - January 2016 and February 2016 - April, 2016 to study the effect of organic manuring practices for improving the quality of Palak (*Beta vulgaris* var. *bengalensis* Hort.) The experiment was laid out in Randomized Block Design with ten treatments and three replications. Among the different treatment combinations the organic treatments of soil application with vermicompost (4t/ha) + liquid nitrogen biofertilizer (*Azospirillum* 200ml/acre) + foliar spray of vermiwash (3%) shown the significant improvement in quality parameters with highest ascorbic acid content (64.35 mg/100g), total phenolic content (23.01mg/100g), total carotenoids (3.96 mg/100g),calcium content (344.77 mg/100g), iron content (15.8 mg/100g), total antioxidant activity (3.43 mg/100g) and shelf life (77.12 mg/ 100g) over the inorganic treatment of soil application with straight fertilizers at 100% RDF(T_{10}). The oxalate content and nitrate content were found to be lowest in all the organic treatments compared to inorganic treatment (T_{10}).

Keywords: Palak, vermicompost, farmyard manure, foliar spray, organic manures

Introduction
Palak (*Beta vulgaris* var. *bengalensis* Hort.) member of the chenopodiaceae family, is also known as Spinach Beet, Beet leaf and Indian Spinach. This particular beet leaf might have been first used in Bengal and that is why it is known as var. *bengalensis*. It is an annual plant and used as a nutritive leafy vegetable. Leafy vegetables are rich source of vitamins, minerals and dietary fibre. Leafy vegetables play a vital role in daily diet of humans with high nutritional values. Palak is rich in vitamins especially vitamin A (97701IU) and other vitamins like ascorbic acid (70mg/100g), riboflavin, and thiamine. There are also appreciable quantities of minerals like iron and calcium (380mg/100g).Leafy vegetables contribute 80-100 g per day per person in daily diet which is 40percent of the daily total vegetable consumption of a person. Organic farming is an age old practice in Indian agriculture which is based on the minimal use of off-farm inputs and on management practices that restore, maintain and enhance ecological harmony. However in the process of modernization, particularly after green revolution the consumption of chemicals namely fertilizers, pesticides and growth regulators etc., have increased substantially in the production system. As leafy vegetables are of short duration and remunerative, farmers use huge amount of nitrogenous fertilizers for quick and luxurious growth which leads to poor quality and shelf life of vegetable. Growing of leafy vegetables with organic practices not only improves the quality but also extends the shelf life. The increased use of organic inputs in the production of horticultural crops is helpful not only for human health but also for plant and soil health. Keeping the facts in view, the present investigation was planned to find out the appropriate combination of organic manures with organic plant growth regulators for improving the quality of palak.

Materials and method
Field experiments were conducted in the farmer's field located at Sandayagoundampalayam in Thondammutur block of Coimbatore district. Geographically, it is located at 11°14' North latitude, 77°10' East longitude and altitude of 338 m above mean sea level. The experiments were conducted in Randomized block design with ten treatments and three replications. The soil texture of the field was sandy loam with pH of 8.1 and EC of 0.22 dSm^{-1} in the I season and pH of 8.3 and EC of 0.24 dSm^{-1} in the II season. The treatments consists of T_1 (soil application with farm yard manure (10t/ha) + liquid nitrogen biofertilizer (*Azospirillum* 200ml/acre) + foliar spray of effective microorganisms (2%)), T_2 (soil application with farm yard manure (10t/ha) + liquid nitrogen biofertilizer (*Azospirillum* 200ml/acre) + foliar spray of humic acid (3%)), T_3 (soil application with farm yard manure (10t/ha) + liquid nitrogen

biofertilizer (*Azospirillum* 200ml/acre) + foliar spray of vermiwash (3%)), T_4 (soil application with vermicompost (4t/ha) + liquid nitrogen biofertilizer (*Azospirillum* 200ml/acre) + foliar spray of effective microorganisms (2%)), T_5 (soil application with vermicompost (4t/ha) + liquid nitrogen biofertilizer (*Azospirillum* 200ml/acre) + foliar spray of humic acid (3%)), T_6 (soil application with vermicompost (4t/ha) + liquid nitrogen biofertilizer (*Azospirillum* 200ml/acre) + foliar spray of vermiwash (3%)), T_7 (soil application with farm yard manure (10t/ha) + soil application with vermicompost (4t/ha) + liquid nitrogen biofertilizer (*Azospirillum* 200ml/acre) + foliar spray of effective microorganisms (2%)), T_8 (soil application with farm yard manure (10t/ha) + soil application with vermicompost (4t/ha) + liquid nitrogen biofertilizer (*Azospirillum* 200ml/acre) + foliar spray of humic acid (3%)), T_9 (soil application with farm yard manure (10t/ha) + soil application with vermicompost(4t/ha) + liquid nitrogen biofertilizer (*Azospirillum* 200ml/acre) + foliar spray of vermiwash (3%)) and T_{10} (control- soil application with straight fertilizers at 100% RDF). The variety All Green was used as the test crop.As per the treatment vermicompost and farmyard manure were applied as soil basal application and the liquid nitrogen biofertilizer *Azospirillum* was applied as drip fertilizer at the rate of 200ml/acre. Vermiwash and humic acid were sprayed on 10,30,45 days after sowing each at 3 percent concentration where as effective microorganisms was applied on10,30,45 days after sowing at 2 percent concentration. The raised beds were formed at a spacing of 45 cm. The gross size of an individual plot was17 m². The separate block of land was used for the inorganic control treatment. For control treatment the straight fertilizer were applied to the soil at the rate of 120:60:60 kg NPK ha^{-1}. The same standard cultural practices were followed for both organic and inorganic plots except plant protection measures. For organic treatments the plant protection measures were carried out by bio pesticides whereas for inorganic treatments, inorganic pesticides were used. Harvesting of the fresh, tender, succulent leaves was done at 25, 45 and 65 days after sowing. The quality parameters of palak leaves *viz.*, such as ascorbic acid (AOAC. 1975) [1], total phenolics (Malik and Singh, 1980) [11], total carotenoids (Jensen, 1978) [7], calcium content (A.O.A.C. 1975) [1], iron content (Jackson, 1973) [4], total antioxidant activity (Umamaheswari and Chatterjee, 2008) [17], nitrate content (Cataldo *et al.*, 1975) [3], oxalate content (A.O.A.C. 1975) [1] and shelf life were estimated on 25DAS and were analysed statistically.

Results and Discussion

Ascorbic acid

The pooled mean of ascorbic acid is presented in the table 1.Among the treatments, the highest mean content of ascorbic acid was recorded in the organic treatment T_6 (soil application with vermicompost @ 4 tonnes/ha + liquid nitrogen biofertilizer (*Azospirillum* @ 200ml/acre) + foliar spray of vermiwash (3%)) with pooled mean value of 64.35 mg /100 g and the lowest ascorbic content of 43.18 mg /100 g was recorded in the inorganic control treatment. The increase in ascorbic acid content in the leaves of palak might be due to application of organic fertilizers along with the biofertilizers which might have helped in better uptake of major nutrients including micronutrients leading to increased biosynthesis of vitamins. This is in accordance with the findings of Jaya Sharma and Sunita Agarwal (2014) [6], Faramarz Ahmadi, and Mehrdad Jafarpour (2015) [2], who stated that the vermicompost application recorded highest ascorbic acid content in spinach by increasing the biosynthesis of vitamins. Viveka and Singh (2005) [18] observed highest ascorbic acid in cauliflower with application of *Azospirillum*, due to to fixation of atmospheric nitrogen and secretion of growth promoting substances which accelerated the physiological and biochemical processes. The similar result was found in cauliflower by Tekasangla and Kanaujia (2015) [16] who observed increase in ascorbic acid due to the action of specific soil nutrients which was made more readily available into the soil for plant absorption by organic manure with biofertilizers integration effect which in turn activated the specific enzymes resposible for the synthesis of glucuronate compounds which is the precursor for the ascorbic acid biosynthesis.

Total phenols

The pooled mean of total phenols is presented in the table 1.The highest mean content of total phenol was recorded in the organic treatment T_6 (soil application with vermicompost @ 4 tonnes/ha +liquid nitrogen biofertilizer (*Azospirillum* 200ml/acre) + foliar spray of vermiwash (3%)) with mean value of 23.01mg/ 100 g. This might be due to increased uptake of the macro and micronutrients by the application of biofertilizers with vermicompost and vermiwash which resulted in increased biosynthesis of phenolic compounds. Similar finding was also reported by Revathi and Subhash Reddy (2014) [12] in spinach beet who observed the increased biosynthesis of phenolic compounds by the use of biofertilizers along with organics.

Total carotenoids

The pooled mean value of total carotenoids is presented in the table 1. Among the treatments, organic treatment of soil application with vermicompost @ 4 tonnes/ha + liquid nitrogen (*Azospirillum* 200ml/acre) + foliar spray of vermiwash (3%) (T_6) recorded highest mean total carotenoids content of 3.96 mg/100 g which was on par with T_5 (soil application with vermicompost(4t/ha)+ liquid nitrogen biofertilizer (*Azospirillum* 200ml/acre)+ foliar spray of humic acid (3%)) of 3.86 mg / 100 g. This might be due to the application of liquid biofertilizer *Azospirillum* which helped in the atmospheric nitrogen fixation and phosphorous solubilization and stimulated the plant growth hormones providing better nutrient uptake and increased biosynthesis of biochemicals of the plant. Similar finding was also observed by Revathi and Subhash Reddy (2014) [12] and Jaya Sharma and Sunita Agarwal (2014) [6] in spinach, who stated that the combination of organic manures along with biofertilizers resulted in highest carotenoid content in spinach. Lowest total carotenoid content of 2.01 mg/100g was recorded by the inorganic control treatment.

Calcium content

The pooled mean value of calcium content is presented in the table 2. The organic treatment of soil application with vermicompost @ 4 tonnes/ha + liquid nitrogen (*Azospirillum* 200ml/acre) + foliar spray of vermiwash (3%) (T_6) recorded the highest calcium content of 343.68 mg / 100g. This might be due to the presence of micronutrients in the organic manures leading to the higher uptake of nutrients by the plant. The result is in accordance with the findings of Roy and Afsar (2015) [13], who stated that the application of organics to the soil resulted in the better uptake of nutrients and regulated the plant growth regulators thereby increased the uptake of both macro and micronutrients in Indian spinach. The similar

findings were also given by Jaya Sharma and Sunita Agarwal (2014) [6] in spinach.

Iron content

The pooled mean of iron content is presented in the table 2. Iron content of palak leaves was found to be more in the organic treatment T_6 (soil application with vermicompost @ 4 tonnes/ha + liquid nitrogen biofertilizer (*Azospirillum* 200ml/acre) + foliar spray of vermiwash (3%)) with the mean of 15.8 mg/100g. The effect of vermicompost on iron uptake might be due to the presence of organic carbon in the applied organic manures which act as a source of energy for soil microorganism, which upon mineralization releases organic acids that decreased the soil pH and improved the availability of iron. This is found to be in accordance with the finding of Roy and Afsar (2015) [13] in Indian spinach who stated that the application of organics to the soil increases the mineralization effect of the soil thereby increases the uptake of micronutrients such as iron. Kavitha *et al*., (2013) reported similar findings in amaranthus.The lowest iron content of 12.95 mg/100g was present in the inorganic treatment of soil application with straight fertilizers at 100% RDF.

Total antioxidant activity

The pooled mean of total antioxidant activity was presented in the table 2. The highest mean of total antioxidant activity with mean value of 3.43 mg/100g was recorded in the organic treatment T_6 (soil application with vermicompost @ 4 tonnes/ha + liquid nitrogen biofertilizer (*Azospirillum* 200ml/acre) + foliar spray of vermiwash (3%)). The increase in antioxidant activity of the plant might be due to the secretion of phytohormones by *Azospirillum* and vermicompost, which helps in nitrogen fixation, production of undefined signaling molecules that can interfere with plant metabolism, nitrite production, and enhancement of mineral uptake by plants there by increased the antioxidant activity. Similar finding was also reported by Revathi and Subhash Reddy (2014) [12] who reported that the use of biofertilizers along with organic manures increased the phytohormone secretion of the plant and enhanced the mineral uptake leading to highest antioxidant activity in Spinach beet. Lowest mean antioxidant activity of 2.04 mg/100g was recorded by the inorganic control treatment of soil application of straight fertilizers at 100% RDF.

Nitrate and oxalate content

Leafy vegetables occupy a very important place in the human diet, but unfortunately constitute a group of foods which contributes maximally to nitrate consumption by living beings. A reduction in nitrate content can add value to vegetable products already very popular for their nutritional and therapeutic properties. In the present study table 3 nitrate and oxalate content were found to be lowest in all the organic treatments when compared to the inorganic control. This might be due to the soil nitrification activity of the biofertilizer *Azospirillum* leading to reduction in the nitrate content of the leaf. This is in accordance with findings of Zahradnik and Petrikova (2007) [19] in head cabbage and Joji Muramoto (1999) [8] in spinach, who stated that the application of organics mainly biofertilizers reduces the nitrate content of the plant. The highest nitrate content was found in the inorganic control treatment (soil application with straight fertilizers at 100%RDF). This result is in line with the findings of Joji Muramoto (1999) [8] in spinach and Sumeet Gairola and Shahid Umar (2007) [14] in spinach beet, who observed that the application of organics to the soil resulted in the nitrification activity of the soil leading to reduction in nitrate accumulation in the plant. Madhavi Latha and Veena Joshi (2013) [9] recorded the lowest oxalate content in amaranthus and palak by the application of organics along with biofertilizers.

Shelf life

The mean value of the shelf life is presented in the table 3. The organic treatment of soil application with vermicompost @ 4 tonnes/ha + liquid nitrogen biofertilizer (*Azospirillum* 200ml/acre) + foliar spray of vermiwash (3%) (T_6) recorded highest mean storage periods of 78.72 hours over the inorganic control (67.77 hours).This might be due to the fact that the biofertilizer *Azospirillum* application might have increased the nitrogen fixation ability of the plant and resulted in higher nutrient uptake which reduced the respiration of the lettuce head. This is in accordance with the findings of Revathi and Subhash Reddy (2014) [12] who stated that the the application of organic manures and biofertilizers led to the reduced respiration and increased the shelflife in spinach beet.

Table 1: Effect of organic manures on the ascorbic acid content (mg/ 100g), total phenols (mg/ 100g) and total carotenoids (mg/ 100g) of the palak var. 'All Green'

Treatments	Ascorbic acid (mg/ 100g)			Total phenols (mg/ 100g)			Total carotenoids(mg/100g)		
	Crop I	Crop II	Mean	Crop I	Crop II	Mean	Crop I	Crop II	Mean
T_1	47.97	47.80	47.88	20.38	20.3	20.33	2.84	2.84	2.84
T_2	51.17	52.10	51.63	20.31	20.42	20.36	2.96	2.95	2.95
T_3	52.20	52.10	52.15	20.39	20.5	20.44	3.07	3.07	3.07
T_4	58.13	56.47	57.30	20.95	21.04	20.99	3.24	3.24	3.24
T_5	60.23	60.87	60.55	20.65	21.2	20.92	3.93	3.79	3.86
T_6	64.20	64.50	64.35	23.07	22.96	23.01	3.96	3.95	3.96
T_7	57.10	56.50	56.80	19.7	20.1	19.9	3.33	3.33	3.32
T_8	51.83	52.10	51.97	20.37	19.9	20.13	3.03	3.03	3.03
T_9	51.87	52.43	52.15	19.71	20.04	19.87	3.23	3.22	3.22
T_{10}	42.97	43.40	43.18	18.21	18.45	18.33	2.02	2.01	2.01
SEd	1.0208	1.2404	1.1359	0.2747	0.3725	0.3273	0.0385	0.1197	0.088
CD (0.05%)	2.1436	2.6049	2.2832	0.5769	0.7823	0.6578	0.0809	0.2514	0.1787

T_1 - Soil application with FYM (10t/ha) + Liquid Nitrogen Biofertilizer (*Azospirillum*200ml/acre) + Foliar spray of effective microorganisms (2%)

T_2 - Soil application with FYM (10t/ha) + Liquid Nitrogen Biofertilizer (*Azospirillum* 200ml/acre) + Foliar spray of humic acid (3%)

T_3- Soil application with FYM (10t/ha) + Liquid Nitrogen Biofertilizer (*Azospirillum* 200ml/acre) + Foliar spray of vermiwash (3%)

T_4- Soil application with Vermicompost (4t/ha) + Liquid Nitrogen Biofertilizer (*Azospirillum*200ml/acre) + Foliar spray of effective

microorganisms (2%)
T_5 - Soil application with Vermicompost (4t/ha) + Liquid Nitrogen Biofertilizer (*Azospirillum* 200ml/acre) + Foliar spray of humic acid (3%)
T_6 - Soil application with Vermicompost (4t/ha) + Liquid Nitrogen Biofertilizer (*Azospirillum* 200ml/acre) + Foliar spray of vermiwash (3%)
T_7 - Soil application with FYM (10t/ha) + T_4
T_8 - Soil application with FYM (10t/ha) + T_5
T_9 - Soil application with FYM (10t/ha) + T_6
T_{10} - Soil application with straight fertilizers at 100% RDF.

Table 2: Effect of organic manures on the calcium content (mg/ 100g), iron (mg 100 g^{-1}), and total antioxidant activity (mg 100 g^{-1}) of the palak var. 'All Green'

Treatments	Calcium content (mg/ 100g)			Iron content (mg/ 100g)			Total antioxidant activity (mg 100 g^{-1})		
	Crop I	Crop II	Mean	Crop I	Crop II	Mean	Crop I	Crop II	Mean
T_1	278.4	287.57	282.98	14.44	14.5	14.47	2.65	2.67	2.66
T_2	265.3	253.37	259.33	14.67	14.23	14.45	2.74	2.56	2.65
T_3	265.57	264.77	265.16	13.92	14.02	13.96	2.33	2.27	2.3
T_4	294.5	292.3	293.4	14.69	15.07	14.88	3.14	2.99	3.06
T_5	302.57	310.03	306.3	15.44	15.21	15.32	2.94	3.01	2.97
T_6	344.77	342.6	343.68	15.84	15.76	15.8	3.45	3.42	3.43
T_7	265.8	273.8	269.8	14.36	14.24	14.3	2.33	2.32	2.32
T_8	265.27	268.33	266.8	14.32	14.13	14.22	2.39	2.36	2.37
T_9	272.73	264.67	268.7	14.13	14.17	14.15	2.21	2.27	2.23
T_{10}	253.37	253.5	253.4	12.9	13.02	12.95	2.05	2.03	2.04
SEd	5.8093	5.378	5.5978	0.3165	0.3841	0.2489	0.0677	0.0521	0.0604
CD (0.05%)	12.199	11.293	11.251	0.6646	0.8067	0.3519	0.1422	0.1095	0.1215

T_1 - Soil application with FYM (10t/ha) + Liquid Nitrogen Biofertilizer (*Azospirillum*200ml/acre) + Foliar spray of effective microorganisms (2%)
T_2 - Soil application with FYM (10t/ha) + Liquid Nitrogen Biofertilizer (*Azospirillum* 200ml/acre) + Foliar spray of humic acid (3%)
T_3- Soil application with FYM (10t/ha) + Liquid Nitrogen Biofertilizer (*Azospirillum* 200ml/acre) + Foliar spray of vermiwash (3%)
T_4- Soil application with Vermicompost (4t/ha) + Liquid Nitrogen Biofertilizer (*Azospirillum*200ml/acre) + Foliar spray of effective microorganisms (2%)
T_5 - Soil application with Vermicompost (4t/ha) + Liquid Nitrogen Biofertilizer (*Azospirillum* 200ml/acre) + Foliar spray of humic acid (3%)
T_6 - Soil application with Vermicompost (4t/ha) + Liquid Nitrogen Biofertilizer (*Azospirillum* 200ml/acre) + Foliar spray of vermiwash (3%)
T_7 - Soil application with FYM (10t/ha) + T_4
T_8 - Soil application with FYM (10t/ha) + T_5
T_9 - Soil application with FYM (10t/ha) + T_6
T_{10} - Soil application with straight fertilizers at 100% RDF.

Table 3: Effect of organic manures on the nitrate content (mg kg^{-1}), oxalate content (mg 100 g^{-1}) and shelf life (hours) of the palak var. 'All Green'

Treatment	Nitrate (mg kg^{-1})			Oxalate (mg 100 g^{-1})			Shelf life (hours)		
	Crop I	Crop II	Mean	Crop I	Crop II	Mean	Crop I	Crop II	Mean
T_1	1827.3	1828.5	1825.9	534.36	530.58	532.47	71.99	74.01	73.00
T_2	1843.6	1826.2	1834.9	539.16	538.26	538.70	74.64	75.12	74.82
T_3	1847.4	1829.5	1838.4	537.63	544.36	540.99	75.35	75.40	75.37
T_4	1828.9	1831.9	1830.4	535.28	546.46	540.87	75.41	76.08	75.71
T_5	1832.2	1831.0	1831.6	541.36	544.05	542.70	77.23	77.03	77.12
T_6	1801.7	1824.5	1812.2	532.36	544.81	538.58	78.93	78.50	78.72
T_7	1832.0	1828.9	1830.3	540.52	539.32	539.92	78.48	75.05	76.74
T_8	1822.4	1831.2	1826.8	535.04	534.16	534.6	74.59	75.06	74.79
T_9	1846.6	1829.0	1837.8	536.97	544.34	540.65	72.79	73.40	73.10
T_{10}	2136.0	2129.0	2132.5	676.36	661.74	669.05	67.55	68.00	67.77
SEd	19.00	41.90	32.53	7.13	11.67	9.67	1.5628	1.6476	1.605
CD (0.05%)	39.91	87.99	65.39	14.98	24.52	19.45	3.2818	3.4599	3.227

T_1 - Soil application with FYM (10t/ha) + Liquid Nitrogen Biofertilizer (*Azospirillum*200ml/acre) + Foliar spray of effective microorganisms (2%)
T_2 - Soil application with FYM (10t/ha) + Liquid Nitrogen Biofertilizer (*Azospirillum* 200ml/acre) + Foliar spray of humic acid (3%)
T_3- Soil application with FYM (10t/ha) + Liquid Nitrogen Biofertilizer (*Azospirillum* 200ml/acre) + Foliar spray of vermiwash (3%)
T_4- Soil application with Vermicompost (4t/ha) + Liquid Nitrogen Biofertilizer (*Azospirillum*200ml/acre) + Foliar spray of effective microorganisms (2%)
T_5 - Soil application with Vermicompost (4t/ha) + Liquid Nitrogen Biofertilizer (*Azospirillum* 200ml/acre) + Foliar spray of humic acid (3%)
T_6 - Soil application with Vermicompost (4t/ha) + Liquid Nitrogen Biofertilizer (*Azospirillum* 200ml/acre) + Foliar spray of vermiwash (3%)
T_7 - Soil application with FYM (10t/ha) + T_4
T_8 - Soil application with FYM (10t/ha) + T_5
T_9 - Soil application with FYM (10t/ha) + T_6
T_{10} - Soil application with straight fertilizers at 100% RDF.

Conclusion

In this study organically grown palak showed increase in all the quality parameters such as ascorbic acid, total phenols, carotenoids, iron content, calcium content, total antioxidant activity and shelflife. The nitrate and oxalate content were found to be low in the organic treatments of soil application with vermicompost @ 4 tonnes/ha + liquid nitrogen biofertilizer (*Azospirillum* 200ml/acre) + foliar spray of vermiwash (3%) (T_6) compared to the control inorganic treatment. Reduction in oxalate and nitrate content in the palak leaves added value to the nutritional quality of palak greens.

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