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Growth and yield performance of Indian spinach (*Basella rubra* L.) under organic nutrient management

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Abstract

Indian spinach is an underutilized perennial vegetable, originated in tropical Asia belonging to the family Basellaceae. It is very hardy vegetable having potential to sustain the high rainfall conditions prevailing in Konkan region which no other leafy vegetable can sustain especially from June to September. In spite of potential, the crop has remained unexploited due to lack of standardization of production protocol. The experimental findings revealed that the treatment T₁₂ found best in plant height (34.30 cm). Among different treatments, T₃ *i. e.* Azotobacter @ 5 kg/ha + PSB @ 5 kg/ha + FYM 10 t/ha + 100% RDF recorded better results in number of leaves (85.70) and total herbage yield per plant (1215.70 g). The highest number of branches (49.40) was recorded in the treatment T₁₁ *i. e.* PSB @ 5 kg/ha + Poultry Manure. The longest shelf life at ambient temperature (23.28 hrs.) was found in the treatment T₉ *i. e.* Azotobacter @ 5 kg/ha + PSB @ 5 kg/ha + Vermicompost @ 5 t/ha.

Keywords: Growth and yield, Indian spinach, *Basella rubra* L.

Introduction

Basella is a fast-growing, heat tolerant perennial vegetable, originated in tropical Asia (India and Indonesia) and belongs to family Basellaceae. The plant is a succulent, branched, smooth, twining and herbaceous vine reaching a length of several meters. The leaves are thick, semi-succulent, heart-shaped having a mild flavour and mucilaginous texture. Basella is commonly grown for its leaves and tender shoots, which are high in Vitamin A, iron, calcium, B9 and Vitamin C. The leaves contain carotenoids, organic acids, water soluble polysaccharides, betacyanin, bioflavonoid and vitamin K. It is a source of many amino acids such as arginine, leucine, isoleucine, threonine, lysine and tryptophan (Khare, 2007) [5].

Basella is a warm season crop, shows better performance in the temperature ranging from 26-28 °C. The climatic condition of Konkan region is warm and humid which is ideal for cultivation of basella. No other leafy vegetable can be grown either in backyard or commercially during June to September. Generally, basella plants are commonly grown naturally in the backyard, where domestic effluents keep the soil moist and nourishes the plant. Now a days, the demand for organically cultivated vegetables is increasing. Many number of organically grown vegetables are selling in market and Basella is one of them. Basella has huge scope however, the issue regarding nutrient management of underutilised vegetable crops, have remained neglected. Many investigators studied the role of organic manures mixed with bio-fertilizer as stimulating the plant growth, yield and quality of plant part. Such practices should be encouraged to minimise the use of inorganic fertilizers, to save natural economy and environment. Hence with a view the work on agronomical aspects on cultivation of basella under Konkan conditions, the present investigation entitled, "Growth and yield performance of Indian spinach (*Basella rubra* L.) Under organic nutrient management" was undertaken.

Materials and Methods

Plant materials

Seed of Indian spinach was sown in portraits filled with cocopeat. Approximately, 1 month after sowing, the seedlings were transplanted with a spacing of 50 cm x 45 cm using Randomized Block Design (RBD). The present field investigation was conducted to stimulate the work on agronomical aspects on cultivation of basella under Konkan conditions during the year 2022-2023 at College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli (M.S.).

Treatments

There were total 15 treatments replicated twice using Randomized Block Design. The treatment combinations are as follows: T₁ - FYM @ 10 t/ha + 100% RDF (100:50:50 NPK kg/ha), T₂ - PSB @ 5 kg/ha + FYM @ 10 t/ha +100% RDF, T₃ - Azotobacter @ 5 kg/ha + PSB @ 5 kg/ha + FYM @ 10 t/ha +100% RDF, T₄ - Azotobacter@ 5 kg/ha + FYM @ 10 t/ha, T₅ - PSB @ 5 kg/ha + FYM @ 10 t/ha, T₆ - Azotobacter @ 5 kg/ha + PSB @ 5 kg/ha + FYM @ 10 t/ha, T₇ - Azotobacter @ 5 kg/ha + Vermicompost @ 5 t/ha, T₈ - PSB @ 5 kg/ha +Vermicompost @ 5 t/ha, T₉ - Azotobacter @ 5 kg/ha + PSB @ 5 kg/ha +Vermicompost @ 5 t/ha, T₁₀ - Azotobacter @ 5 kg/ha + Poultry Manure @ 4 t/ha, T₁₁ - PSB @ 5 kg/ha + Poultry Manure @ 4 t/ha, T₁₂ - Azotobacter@ 5 kg/ha + PSB @ 5 kg/ha + Poultry Manure @ 4 t/ha, T₁₃ - Azotobacter @ 5 kg/ha + Neem Cake @ 2 t/ha, T₁₄ - PSB @ 5 kg/ha +Neem Cake @ 2 t/ha, T₁₅ - Azotobacter@ 5 kg/ha + PSB @ 5 kg/ha +Neem Cake @ 2 t/ha. Growth parameters (Plant height (cm), stem diameter (mm), number of leaves, number of branches, internodal length (cm)) and yield

contributing characters and yield were studied.

Results and Discussion

Plant height

The data in relation to the plant height of Indian spinach varied significantly throughout the experimental period (Table.1). Applying PSB @ 5 kg/ha + FYM @ 10 t/ha +100% RDF (T₂) enhanced plant height of Indian spinach from 30 to 90 days after planting (DAP), 270 DAP (37.40 cm) and 300 DAP (35.90 cm). Applying Azotobacter @ 5 kg/ha + PSB @ 5 kg/ha + FYM @ 10 t/ha +100% RDF (T₃) resulted in better plant height from 180 to 240 DAP (40.60, 39.20 and 40.10 cm resp.). However, at 120 DAP significantly, the highest plant height (41.90 cm) was recorded with Azotobacter @ 5 kg/ha + Poultry Manure @ 4 t/ha (T₁₀) (Table.1). Further, at 150 DAP, the highest plant height (37.10 cm) was reported in the treatment PSB @ 5 kg/ha + Poultry Manure @ 4 t/ha (T₁₁). Applying Azotobacter @ 5 kg/ha + PSB @ 5 kg/ha + Poultry Manure @ 4 t/ha (T₁₂) showed highest plant height (34.30 cm) at 330 DAP.

Table 1: Effect of various nutrient combinations on plant height (cm) of Indian spinach

Treatment	Plant Height (cm)										
	Days After Planting (DAP)										
	30	60	90	120	150	180	210	240	270	300	330
T ₁	24.80	23.00	38.00	33.19	36.30	34.30	34.70	36.50	36.50	34.40	30.80
T ₂	28.10	26.60	49.30	39.08	35.00	35.40	35.70	36.80	37.40	35.90	33.10
T ₃	23.90	25.70	49.20	36.10	32.55	40.60	39.20	40.10	36.90	33.50	30.70
T ₄	18.80	23.40	40.40	31.90	30.85	33.70	35.10	37.70	36.90	33.60	32.00
T ₅	19.60	21.10	34.90	26.95	24.80	29.60	30.70	32.30	33.70	32.70	32.10
T ₆	19.50	21.50	31.40	29.75	30.55	28.50	30.00	31.10	32.40	29.00	29.20
T ₇	25.40	23.00	37.00	31.70	32.65	34.40	35.10	34.90	34.30	30.50	29.20
T ₈	20.90	26.50	32.70	27.93	24.30	26.10	28.30	31.60	33.30	31.00	30.30
T ₉	20.10	20.70	37.20	29.70	32.40	29.60	31.70	32.90	33.20	31.60	28.70
T ₁₀	27.30	22.40	39.80	41.90	36.90	33.30	33.90	33.90	35.70	31.90	31.20
T ₁₁	22.30	26.00	44.20	39.55	37.10	33.30	33.20	34.70	34.90	32.40	29.90
T ₁₂	20.70	23.00	25.50	25.20	24.30	25.90	28.30	30.70	31.80	30.60	34.30
T ₁₃	15.50	18.90	22.80	19.30	17.00	21.30	23.60	24.20	24.40	24.30	25.20
T ₁₄	15.10	16.00	21.90	23.40	23.80	21.80	24.30	27.50	27.00	25.00	25.30
T ₁₅	18.90	19.10	36.20	26.40	24.00	24.10	25.50	26.80	26.40	25.60	25.70
Mean	21.39	22.46	36.03	30.80	29.50	30.13	31.29	32.78	32.99	30.8	29.85
Range	15.10-28.10	16-26.60	21.90- 49.30	19.30- 41.90	17- 37.10	21.30- 40.60	23.60- 39.20	24.20-40.10	24.40- 37.40	24.30-35.90	25.20-34.30
F test	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG
SEm±	0.23	0.27	0.34	0.34	0.30	0.33	0.33	0.30	0.34	0.30	0.32
CD (5%)	0.69	0.82	1.04	1.03	0.91	0.99	1.01	0.91	1.02	0.91	0.97

Stem diameter

Data regarding the effect of various nutrient combinations on stem diameter of Indian spinach showed a significant difference among all the treatments applied from 30 upto 300 DAP (Table 2). From 90 DAP to 300 DAP, the highest stem diameter (16.24 mm at 300 DAP) was recorded in the treatment T₁₀ *i. e.* Azotobacter @ 5 kg/ha + Poultry Manure @ 4 t/ha (Table 2). At 330 DAP there was no significant difference between the effect of treatments on stem diameter.

Number of leaves

At 30 DAP, the highest number of leaves (17.40) was recorded in the treatment T₁ *i. e.* FYM @ 10 t/ha + 100% RDF (100:50:50 NPK kg/ha) (Table. 3). At 60 DAP, the highest number of leaves (29.90) was recorded in the treatment T₁₀ *i. e.* Azotobacter @ 5 kg/ha + Poultry Manure @ 4 t/ha (Table 3). However, from 90 DAP to 330 DAP, the highest number of leaves (85.70) was recorded in the treatment T₃ *i. e.* Azotobacter @ 5 kg/ha + PSB @ 5 kg/ha + FYM @ 10 t/ha +100% RDF (Table 3).

Table 2: Effect of various nutrient combinations on stem diameter (mm) of Indian spinach

Treatment	Stem diameter (mm)										
	Days After Planting (DAP)										
	30	60	90	120	150	180	210	240	270	300	330
T ₁	4.95	6.84	9.45	12.64	13.00	13.33	13.64	13.87	14.16	14.43	14.79
T ₂	5.08	8.15	12.01	13.79	14.32	14.60	14.83	14.98	15.17	15.49	15.79
T ₃	5.16	8.05	12.26	14.61	15.00	15.21	15.35	15.51	15.78	15.99	16.46
T ₄	4.35	6.72	9.92	12.34	12.66	12.93	13.16	13.38	13.62	13.93	14.4
T ₅	4.40	6.55	9.34	12.27	12.77	13.07	13.31	13.64	13.91	14.62	14.96
T ₆	4.43	7.16	10.31	11.93	12.27	12.65	12.95	13.02	13.34	13.91	14.31
T ₇	4.57	6.74	10.39	12.69	13.01	13.28	13.50	13.72	13.96	14.24	14.68
T ₈	4.32	8.32	10.18	12.59	13.12	13.33	13.55	13.85	14.05	14.42	14.89
T ₉	4.29	7.11	10.70	11.73	12.16	12.53	12.90	13.09	13.32	13.68	15.1
T ₁₀	4.93	7.76	13.31	15.16	15.53	15.76	15.67	15.85	16.04	16.24	16.09
T ₁₁	4.43	8.25	11.36	12.98	13.42	13.79	14.10	14.41	14.79	15.25	15.87
T ₁₂	4.29	7.35	10.70	11.59	12.12	12.54	12.89	13.13	13.13	13.40	13.81
T ₁₃	3.83	6.80	8.64	10.42	10.83	11.29	11.64	11.99	12.58	12.86	13.27
T ₁₄	3.87	6.84	9.15	10.34	10.83	11.34	11.53	11.84	12.13	12.61	13.02
T ₁₅	3.98	7.09	9.27	10.98	11.58	12.07	12.36	12.67	13.07	13.45	14.21
Mean	4.46	7.32	10.47	12.40	12.84	13.18	13.43	13.66	13.94	14.30	14.78
Range	3.83-5.16	6.55- 8.30	8.64-13.30	10.34-15.16	10.83-15.53	11.29-15.76	11.53-15.67	11.84-15.85	12.13-16.04	12.61-16.24	13.02-16.09
F test	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	NS
SE±	0.24	0.17	0.17	0.20	0.25	0.30	0.34	0.35	0.38	0.48	0.66
CD (5%)	0.72	0.53	0.50	0.61	0.74	0.92	1.03	1.06	1.15	1.45	-

Table 3: Effect of various nutrient combinations on number of leaves of Indian spinach

Treatment	Number of leaves										
	Days After Planting (DAP)										
	30	60	90	120	150	180	210	240	270	300	330
T ₁	17.40	18.10	30.70	54.50	55.90	59.50	61.30	63.60	68.10	72.60	79.80
T ₂	14.50	20.60	34.20	57.90	56.80	59.30	61.10	61.80	69.50	74.80	79.80
T ₃	16.50	23.60	38.60	62.80	62.40	65.20	67.30	68.50	73.90	77.40	85.70
T ₄	11.80	16.60	20.90	40.20	45.80	48.80	51.90	54.30	60.20	63.70	71.90
T ₅	11.60	15.60	19.70	35.90	37.50	40.50	44.00	45.70	52.00	60.00	66.30
T ₆	11.90	25.80	24.70	42.60	45.10	48.40	50.40	54.00	59.30	63.90	69.40
T ₇	13.10	28.20	26.70	35.80	39.20	42.80	44.50	47.00	52.30	57.00	64.00
T ₈	10.80	17.80	16.70	37.40	37.30	41.90	42.70	46.00	53.90	59.40	65.40
T ₉	11.00	29.80	31.30	28.10	32.90	38.60	40.60	44.90	49.60	54.30	60.00
T ₁₀	17.10	29.90	32.90	54.30	53.90	56.10	57.50	60.30	63.20	68.50	76.50
T ₁₁	13.90	22.00	30.70	53.40	55.20	58.30	61.20	63.90	68.30	73.10	78.80
T ₁₂	13.60	19.60	20.40	45.60	52.30	58.90	59.80	62.90	69.30	72.80	80.00
T ₁₃	11.30	24.60	22.70	45.00	44.60	46.90	48.80	49.00	54.70	60.20	66.00
T ₁₄	12.00	22.50	21.00	24.30	24.70	28.00	31.40	33.60	38.00	41.40	47.80
T ₁₅	10.40	24.20	23.60	21.30	24.90	28.80	30.70	34.20	38.40	44.00	51.10
Mean	13.13	22.59	26.32	42.61	44.57	48.13	50.21	52.65	58.05	62.87	69.50
Range	10.40-17.40	15.60-29.90	16.70-38.60	21.30-62.80	24.70-62.40	28-65.20	30.70-67.30	33.60-68.50	38-73.90	41.40-77.40	47.80-85.70
F test	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG
SE±	1.20	1.11	1.22	1.14	1.44	1.45	1.05	0.79	0.75	1.00	0.82
CD (5%)	3.65	3.37	3.69	3.47	4.36	4.41	3.19	2.39	2.26	3.03	2.50

Number of branches

At 30 DAP, there was no significant difference among the effect of different treatments in Indian spinach. However, from 60 DAP to 120 DAP and at 210 DAP, the highest number of branches was recorded in the treatment T₁₀ *i. e.*

Azotobacter @ 5 kg/ha + Poultry Manure @ 4 t/ha (Table 4). From 150 DAP onwards, the highest number of branches (49.40 at 330 DAP) was observed in the treatment T₁₁ where PSB @ 5 kg/ha + Poultry Manure @ 4 t/ha was applied (Table 4).

Table 4: Effect of various nutrient combinations on number of branches of Indian spinach

Treatment	Number of branches										
	Days After Planting (DAP)										
	30	60	90	120	150	180	210	240	270	300	330
T ₁	1.50	4.60	6.60	9.10	11.30	16.80	24.40	33.10	37.90	41.30	44.90
T ₂	1.70	3.90	5.70	9.10	10.30	15.70	23.20	33.10	37.90	41.60	45.60
T ₃	1.60	4.50	6.60	9.50	11.70	17.50	24.20	35.80	39.80	43.40	47.30
T ₄	1.50	3.90	5.60	7.00	10.10	16.10	22.90	33.70	37.40	41.10	44.60
T ₅	1.20	3.90	5.40	6.20	9.10	14.50	21.70	33.20	36.70	40.00	43.00
T ₆	1.70	4.50	5.20	8.00	9.80	15.60	23.20	34.60	38.30	41.70	45.00
T ₇	1.50	3.70	5.80	8.20	11.00	17.40	24.90	36.90	41.20	44.20	47.50
T ₈	1.30	4.30	5.50	8.20	10.70	16.10	23.40	35.00	38.70	42.10	45.00
T ₉	1.80	3.70	5.00	7.00	9.50	15.00	22.70	33.20	36.70	39.70	43.20
T ₁₀	1.70	4.70	7.20	9.50	11.70	17.80	25.60	36.70	41.10	45.00	48.80
T ₁₁	1.60	3.10	5.90	9.10	12.00	18.00	25.30	37.90	41.50	45.10	49.40
T ₁₂	1.60	4.50	6.20	7.90	9.80	16.40	24.20	35.60	38.90	42.80	45.80
T ₁₃	2.10	2.40	3.20	4.00	6.50	13.60	20.00	30.30	34.20	37.80	41.20
T ₁₄	1.80	3.50	4.10	4.60	7.70	14.00	20.40	30.80	35.30	38.60	41.60
T ₁₅	1.30	3.10	4.40	5.50	8.40	14.10	20.30	31.20	35.80	40.10	44.10
Mean	1.59	3.89	5.49	7.53	9.97	15.91	23.09	33.41	37.49	40.70	44.47
Range	1.20-2.10	2.40-4.70	3.20-7.20	4-9.50	6.50-12	13.60-18	20-25.60	30.30-37.90	34.20-41.50	37.80-45.10	41.20-49.40
F test	NS	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG
SEm±	0.34	0.27	0.32	0.57	0.29	0.42	0.44	0.54	0.50	0.48	0.46
CD (5%)	-	0.81	0.97	1.73	0.89	1.28	1.34	1.63	1.51	1.46	1.39

Internodal length

The effect on internodal length of Indian spinach due to all the treatments were varied non-significantly throughout the experimental period except at 30 DAP (3.51 cm in T₈). Applying PSB @ 5 kg/ha + Vermicompost @ 5 t/ha (T₈) resulted into the highest internodal length.

Total herbage yield per plant

The data pertaining to the total herbage yield per plant as influenced by various nutrient combinations are graphically depicted in Fig. 1. The highest total herbage yield per plant (1215.70 g) was recorded in the treatment T₃ (Azotobacter @ 5 kg/ha + PSB @ 5 kg/ha + FYM @ 10 t/ha +100% RDF).

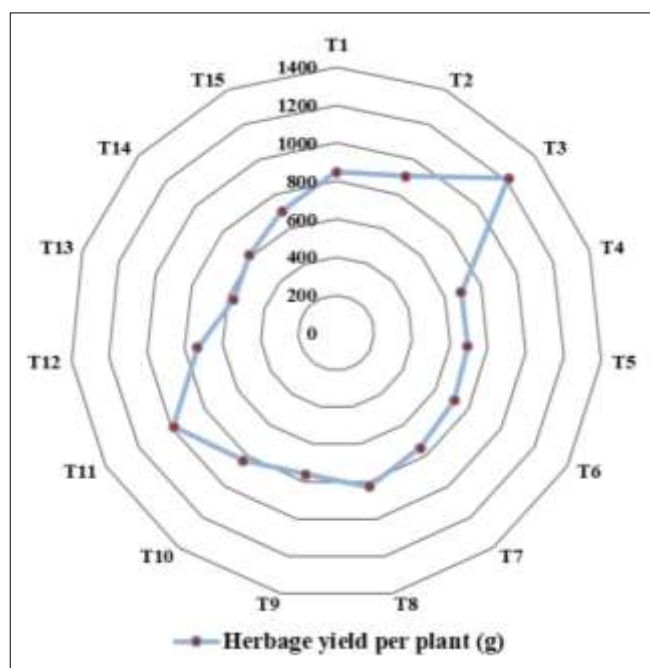


Fig 1: Effect of various nutrient combinations on herbage yield per plant (g) in Indian spinach

Discussion

The above results revealed that the treatments T₂ and T₃ recorded better plant height during the investigation. This is in concurrence with those of Padmanabha *et al.* (2009) [6] in palak and Singh *et al.* (2021) [7] in spinach. Plant height is one of the major growth parameters, which is strongly associated with life span, biomass, maturity and yield. The height of a plant depends on plant vigour and growth habit. Indian spinach is a vigorous growing plant and organic matter had a significant effect on the length of vines. The maximum plant height due to higher availability of nutrients was recorded in the treatments containing combination of inorganic fertilizers, FYM and PSB.

Application of Azotobacter (5 kg/ha) + Poultry Manure (4 t/ha) produced the highest stem diameter during the active growth period in Indian spinach. Similarly, application of PSB @ 5 kg/ha + Poultry Manure @ 4 t/ha produced many branches as compared to control. Poultry manure is a rich source of nutrients (0.8% K, 0.4-0.5% P and 0.9-1.5% N), easily available and cheap source of plant nutrients. Along with nitrogen fixation, azotobacter helps to increase nutrient availability and helps to restore soil fertility for better crop response. Similar results were also obtained by Ahmad *et al.* (2017) [2] in coriander and Chaudhary *et al.* (2018) [3] in amaranth.

In Indian spinach, applying Azotobacter @ 5 kg/ha + PSB @ 5 kg/ha + FYM @ 10 t/ha + 100% RDF produced many large leaves. This implies that there was increased cell division (mitotic activity) and enlargement resulting in highest number of leaves. This is in concurrence with those of Padmanabha *et al.* (2009) [6] in palak and Vasmate *et al.* (2008) [8] in coriander.

Application of Azotobacter @ 5 kg/ha + PSB @ 5 kg/ha + FYM @ 10 t/ha + 100% RDF was effective in increasing total herbage yield per plant. The mineral fertilizers as well as other sources of nutrients such as organic manures and microbial inoculants are necessary to make up the required amount of nutrients in soil. Application of organic manure like FYM can develop a biologically active soil which ensures

good herbage yield. Our findings are supported by Gunjal (2010)^[4] in amaranth and Singh *et al.* (2021)^[7] in spinach.

Conclusion

From the present investigation it was concluded that the treatment T₃ (Azotobacter @ 5 kg/ha + PSB @ 5 kg/ha + FYM @ 10 t/ha +100% RDF) was found to be the best for the yield maximization of Indian spinach (*Basella rubra* L.) under Konkan agroclimatic conditions. Also, when poultry manure is applied supplemented with biofertilizers like azotobacter and PSB the better results are obtained for stem diameter and profuse branching in Indian spinach.

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