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Influence of bioslurry on the growth, yield and nutritional status of Indian Spinach

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ABSTRACT

The fertility and productivity of cultivable land has been declining day by day due to imbalance use of chemical fertilizers. Therefore, a pot experiment was conducted at the shade house of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh during the period from February, 2018 to March, 2019 in order to evaluate the influence of bioslurry on growth, yield and nutritional status of Indian spinach. The two-factor experiment comprised with two varieties of Indian spinach viz., BARI Puishak-1 and BARI Puishak-2 and five levels of bioslurry namely no bioslurry and no fertilizer (control), 10, 15, 20 ton/ha bioslurry and recommended dose of inorganic fertilizers. The experiment was laid out in a randomized complete block design with five replications. Results showed that BARI Puishak-2 performed superior in respect of growth, yield contributing traits and nutritional constituents as compared to BARI Puishak-1. In case of treatments, the highest value of vine length, leaf number, branches per plant, leaf area, dry mater, yield and nutrients (phosphorus, potassium, sulfur, calcium, and sodium) were achieved from the recommended inorganic fertilizers while those parameters were the lowest in control plants. The combination of BARI Puishak-2 with recommended inorganic fertilizers showed the highest vine length, leaf number, number of branch per plant, stem diameter, leaf area, dry mater, yield and nutritional status, while those parameters were lowest in BARI Puishak-1 with control treatment. However, the results of the study revealed that bioslurry 20 ton/ha showed nearly similar performance as recommended inorganic fertilizers. Since, bioslurry contains sufficient amount of nitrogen, potassium and phosphorous, therefore, it could be the effective alternative sources of nutrients instead of chemical fertilizers for sustainable and eco-friendly production of Indian spinach.

Introduction

Indian spinach (*Basella alba* L.) commonly known as Puishak, belongs to the family Basellaceae, is a popular tropical leafy green vegetable commonly used in the diet of human beings. It is a popular summer leafy vegetable widely cultivated and commonly found in the home gardens in Bangladesh, India, and Africa. It is a very popular vegetable in Bangladesh and its demand is increasing day by day for its succulent, nutritious green tender stems and wholesome phyto-nutrients profile.

There are mainly two distinct types of Indian spinach *Basella alba* and *Basella rubra,* one with green petioles and stems and the other with reddish leaves, petioles and stems (Bose and Som, 1990). There are two varieties available in our country. They are BARI Puishak-1 and BARI Puishak-2. Nutritive value of Indian spinach is very high with a good content of minerals and a moderate storage of vitamins to the human diet plus substantial amount of fibre and water (Ghosh and Guha, 1933). It contains an incredibly good amount of vitamins, minerals, and antioxidants (Adhikari *et al.,* 2012). The plant is reported to contain moisture 93%, protein 1.2%, iron 1.4%, calcium 0.15%, vitamin A and vitamin C. Moreover, it is anadyne, sedative, diuretic and expectorant (Kallo, 1986). *Basella* leaves are very rich sources of minerals like potassium, manganese, calcium, magnesium, and copper. Potassium is an important component of cell and body fluids that helps controlling heart rate and blood pressure. Indian spinach is an excellent source of iron, an important trace element, required by the human body for red blood cell (RBC's) production. Indian spinach has been used from a long time back for the treatment of many diseases like dysentery, diarrhoea, anaemia, cancer, etc. (Adhikari *et al.,* 2012). The juice of leaves is prescribed in cases of constipation, particularly for children and pregnant woman (Burkill, 1935).

Bangladesh is an agricultural country where limited cultivable land is forced to maximize crop yields per unit area by intensive use of land and soil resources. The soil fertility and productivity of soils of Bangladesh has been declining day by day due to continuous mining of nutrients, crop intensification and imbalanced use of chemical fertilizers with little or no addition of organic

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fertilizers. Organic matter content in Bangladesh soil is alarmingly low around 1% in most and 2% in few soils, where it should be maintained at least 3% (Islam, 2006). Despite the large quantities of plant nutrients contained in inorganic fertilizers as compared to organic nutrients, the presence of growth promoting agents in organic fertilizers make them important for enhancement of soil fertility and productivity (Sanwal *et al.,* 2007).

Biogas dregs and slurry are by-products of biogas generated during gas production. These residues, especially biogas slurry, are a good source of plant nutrients and can improve soil properties. The chemical fertilizers used for crop production are still at inadequate rates (Girma, 2016). The residues obtained from the biogas plant may be considered as a good source of organic fertilizer as it contains considerable amounts of both macro and micronutrients (Bachmann *et al.,* 2011). Biogas technology is becoming popular in rural area (Hossain *et al.*, 2013). Bioslurry is a 100% organic fertilizer most suitable for organic farming for some high value field and horticultural crops (Islam, 2006). Yield responses of vegetable crops to bioslurry application have been reported in different crops including okra (Shahabz*,* 2011), maize and cabbage (Karki*,* 2001). The use of cow dung biogas residues in Indian spinach production has not been tested in Bangladesh. A very few studies on growth, yield and development of Indian spinach has been carried out in our country. Therefore, growing inorganic fertilizer free healthy leafy Indian spinach there is a huge scope of using bioslurry. Under such circumstance, this study was conducted to find out suitable dose and effects of bioslurry on better growth and higher yield of Indian spinach.

Materials and Methods

The pot experiment

The pot experiment was conducted at the shade house of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh following Randomized Complete Block Design (RCBD) with two factors and five replications.

Factor A: Two varieties of Indian spinach, viz., V_1=BARI Puishak-1, V_2=BARI Puishak-2

Factor B: Five levels of bioslurry, viz., T_1= Control (No bioslurry and No fertilizer), T_2= 10 ton Bioslurry ha^{-1}, T_3= 15 ton Bioslurry ha^{-1}, T_4= 20 ton Bioslurry ha^{-1}, T_5= 120 kg N, 25 kg P, 80 kg K and 20 kg S (Recommended dose, According to FRG, 2012) ha^{-1}

Residues of biogas plant commonly known as Bioslurry (Palli Joibo Sar) were collected from Rural Development Academy (RDA), Bogura. Soil samples were air dried, larger and massive aggregates were broken down by gentle crushing with wooden pluck. Dry roots, grasses and other particulate materials were removed from the soil. Ten kilograms soil or soil and bioslurry mixture according to the treatment was placed in each earthen pot. Each block consisted of 10 earthen pots, where 5 treatments were allotted at random. The size of each pot was 25 cm×25 cm×20 cm. The distance between the pots and the blocks were 50 cm and 70 cm, respectively. The fertilizer doses of N, P and K were applied from Urea, TSP and MP, respectively. Half N and K, and whole of P were applied during soil preparation. Remaining N and K were applied in two equal instalments after 2 and 4 weeks of seedling emergence. All of biogas plant residues were applied as basal during soil preparation and soils mixed with biogas plant residues were allowed to equilibrate for 4 weeks prior to sowing seeds. Three healthy and uniform seeds of Indian spinach were sown at equal distance in each pot. After two weeks of seedling emergence, one seedling was kept in each pot. Care was taken to keep uniform seedlings in the pots. Irrigation was applied as and when necessary. The experimental pots were kept free of weeds by regular weeding. To control the pests and diseases, necessary plant protection measures were done as and when required.

Data collection

Data were recorded for numbers of leaves per plant, leaf area (cm^2), number of branches per plant, stem diameter (cm), fresh weight of leaf and stem (kg), dry matter of leaf (%), yield per pot (g), yield per hectare (ton), phosphorus content (%P), Sulphur content (%S), Potassium content (%K), Sodium content (%Na), Calcium content (%Ca) following measuring methods or equipments: measuring scale, leaf area meter, counting number, slide callipers, digital balance, dry matter (%) = (dry weight/ fresh weight)× 100, digital balance, counting weight, spectrophotometer, spectrophotometer, flame emission spectrophotometer, flame emission spectrophotometer, flame emission spectrophotometer respectively. Harvestings were done at 40, 60, 80, 100 days after sowing.

Statistical analysis

The significance of differences between the means of the treatments was evaluated by one way analysis of variance followed by Duncan's Multiple Range Test at the significance level of 5% and least significance difference (LSD) test at 5 and 1% level of probability (Gomez and Gomez, 1984). The statistical software Excel and MSTAT-C computer package program developed by Russel (1986) were used for these analyses.

Results

Plant height

There was significant difference found between the two Indian spinach varieties in case of plant height**.** Higher plant height (215.8 cm) was observed from V_2-BARI Puishak-2 while lower plant height (180.7 cm) was observed from V_1-BARI Puishak-1 at 100 days after sowing (Table 1). Plant height of Indian spinach was significantly influenced by different levels of bioslurry at different days after sowing (DAS). At 100DAS, the

highest plant height (345.5 cm) was observed from treatment T_5 (Recommended NPKS) and lowest plant height (58.00 cm) was observed from control treatment T_1 (Table 2). Plant height (vine length) was significantly influenced by the combined effects of variety and different levels of bioslurry treatments. Although the different treatment combinations showed a gradual increasing trend in plant height of Indian spinach at 40, 60, 80, 100 DAS (Table 3) which were statistically significant. However, at 100DAS, the tallest plant (431cm) was obtained from V_2T_5. The shortest plant (56.60 cm) was recorded from V_1T_1 (Table 3).

Table 1. Effect of variety on physiological characters of Indian spinach

Variety	Plant height (cm)	No. of leaves plant^{-1}	No. of branches plant^{-1}	Stem diameter (cm)	Leaf area (cm^2)	Dry matter (%)	Yield (g plant^{-1})
BARI Puishak-1	180.70	81.44	9.20	1.32	124.07	5.21	232.10
BARI Puishak-2	215.80	87.80	9.80	1.46	161.32	6.13	243.90
LSD(0.01)	13.62	3.71	0.91	0.05	2.05	0.1	3.96
Level of sig.	**	**	ns	**	**	**	**
CV (%)	8.93	5.7	12.45	5.21	1.86	2.32	2.16

** = Significant at 1% level of probability, ns= Non significant

Table 2. Effect of different treatments of bioslurry on physiological characters of Indian spinach

Treatment	Plant height (cm)	No. of leaves plant^{-1}	No. of branches plant^{-1}	Stem diameter (cm)	Leaf area (cm^2)	Dry matter (%)	Yield (g plant^{-1})
T_1 (Control)	58.00	35.10	5.10	1.29	84.37	4.54	124.90
T_2 (10 ton/ha bioslurry)	156.70	77.00	10.50	1.48	101.10	5.36	238.50
T_3 (15 ton/ha bioslurry)	197.20	85.60	9.60	1.19	140.70	5.41	232.10
T_4 (20 ton/ha bioslurry)	234.00	105.20	10.70	1.60	189.40	6.26	287.00
T_5 (Recommended NPKS)	345.50	120.20	11.60	1.37	197.90	6.79	307.60
LSD(0.01)	21.53	5.86	1.44	0.09	3.23	0.16	6.26
Level of sig.	**	**	**	**	**	**	**
CV (%)	8.93	5.7	12.45	5.21	1.86	2.32	2.16

** = Significant at 1% level of probability

Table 3. Effect of interaction of variety and treatment on plant height at different days after sowing (DAS) of Indian spinach

Treatments combination		Plant height (cm) at different DAS			
		40	60	80	100
V1:BARI Puishak-1	T_1 (Control)	9.80	30.20	56.40	56.60
	T_2 (10 ton/ha bioslurry)	118.20	138.20	140.40	143.00
	T_3 (15 ton/ha bioslurry)	133.40	152.60	177.40	217.00
	T_4 (20 ton/ha bioslurry)	178.80	198.80	241.00	227.00
	T_5 (Recommended NPKS)	380.80	399.00	428.20	260.00
V2:BARI Puishak-2	T_1 (Control)	11.80	33.80	54.60	59.40
	T_2 (10 ton/ha bioslurry)	101.80	120.20	141.20	170.40
	T_3 (15 ton/ha bioslurry)	172.40	192.80	215.00	177.40
	T_4 (20 ton/ha bioslurry)	174.00	194.00	224.20	241.00
	T_5 (Recommended NPKS)	211.40	228.00	257.40	431.00
LSD(0.01)		31.64	30.57	30.38	30.45
Level of sig.		**	**	**	**
CV (%)		12.33	10.53	8.97	8.93

** = Significant at 1% level of probability

Table 4. Effect of interaction of variety and treatment on number of leaves per plant at different days after sowing (DAS) of Indian spinach

Treatments combination		Number of leaves per plant at different DAS			
		40	60	80	100
V1:BARI Puishak-1	T_1 (Control)	9.40	26.40	33.40	34.20
	T_2 (10 ton/ha bioslurry)	46.20	66.80	77.40	78.20
	T_3 (15 ton/ha bioslurry)	63.00	80.40	87.80	88.80
	T_4 (20 ton/ha bioslurry)	75.40	92.60	99.80	101.80
	T_5 (Recommended NPKS)	62.20	87.20	102.2	104.20
V2:BARI Puishak-2	T_1 (Control)	6.00	25.60	35.20	36.00
	T_2 (10 ton/ha bioslurry)	39.40	62.20	75.00	75.80
	T_3 (15 ton/ha bioslurry)	49.60	70.60	81.60	82.40
	T_4 (20 ton/ha bioslurry)	82.60	100.20	107.8	108.60
	T_5 (Recommended NPKS)	90.40	117.80	135.2	136.20
LSD(0.01)		9.92	8.60	7.74	8.29
Level of sig.		**	**	**	**
CV (%)		11.00	6.85	5.39	5.70

** = Significant at 1% level of probability

Number of leaves per plant

Higher number of leaves per plant (87.80) was observed from V_1-BARI Puishak-2 while lower number of leaves per plant (81.44) was observed from V_2-BARI Puishak-1. There was significant difference found among the two Indian spinach varieties in case of number of leaves per plant (Table 1). The number of leaves per plant was significantly influenced by different treatments in all observations under the study. The number of leaves per plant showed gradually increased with different treatments. The maximum (120.20) number of leaves per plant was recorded from treatment T_5 and minimum (35.10) was recorded from treatment T_1at 100 days after seed sowing (Table 2). Significant differences were recorded for the combined effect of bioslurry and variety on number of leaves per plant showed at 40, 60, 80 and 100DAS. The highest (136.20) number of leaves per plant was found from combination V_2T_5, the second highest (108.60) was found from V_2T_4, while V_1T_1 gave the lowest (34.20) number of leaves per plant (Table 4).

Number of branches per plant

Number of branches per plant was statistically similar due to the different Indian spinach varieties. At 100 DAS, the higher (9.80) number of branches per plant was recorded from V_2-BARI Puishak-2 which was closely followed by V_1-BARI Puishak-1 which was lower (9.20) number of branches per plant (Table 1). Statistically significant differences were recorded due to different levels of bioslurry on number of branches per plant of Indian spinach at 40, 60, 80, and 100 DAS. At 100 DAS, the highest (11.60) number of branches per plant was recorded from treatment T_5 and which was statistically similar to treatment T_4 (10.70) and treatment T_2 (10.50) the lowest (5.10) number of branches per plant was recorded from treatment T_1 (Table 2). Combined effect of treatments and varieties on number of branches per plant showed significant differences. At 100DAS, the highest (12.00) number of branches per plant was recorded from V_2T_5 and V_1T_3, while V_1T_1 gave the lowest (4.80) number of branches per plant. The highest (7.40) number of branches per plant was recorded from V_1T_5, while V_1T_1 gave the lowest (1.00) number of branches per plant at 45 DAS (Table 5).

Stem diameter

Stem diameter was significantly influenced by different varieties in all observations under the study. Higher stem diameter (1.46 cm) was observed from BARI Puishak-2 while lower stem diameter (1.32 cm) was observed from BARI Puishak-1 (Table 1). Significant variation was found due to the different treatments on stem diameter of Indian spinach. The highest (1.61 cm) stem diameter was recorded from T_4 and the lowest (1.29 cm) stem diameter was observed from T_1 (Table 2). Combine effect of different treatments and varieties on stem diameter showed highly significant differences. The highest (1.69 cm) stem diameter was recorded from V_2T_4. V_1T_3 gave the lowest (1.13 cm) stem diameter (Table 6).

Leaf area

Leaf area was significantly influenced by different varieties in all observations under the study. The highest leaf area (161.32 cm^2) was observed from V_2-BARI Puishak-2 while the lowest leaf area (124.07 cm^2) was observed from V_1-BARI Puishak-1. There was significant difference found among the two Indian spinach varieties in case of leaf area (Table 1). Significant variation was found due to the different treatments on leaf area of Indian spinach. The highest (197.90 cm^2) leaf area was recorded from T_5 and the lowest (84.37 cm^2) leaf area was observed from T_1 (Fig. 1). Combine effect of different treatments and varieties on leaf area showed highly significant differences. The highest (221.70 cm^2) leaf area was recorded from V_2T_5. V_1T_2 gave the lowest (58.08 cm^2) leaf area (Table 6).

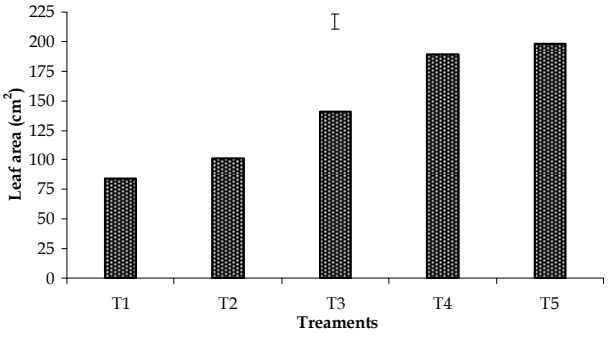

Fig. 1. Effect of treatments on leaf area of Indian spinach. T_1= control, T2= 10 ton/ha bioslurry, T3= 15 ton/ha bioslurry, T4= 20 ton/ha bioslurry, T5= Recommended NPKS. Vertical bar represent LSD at 5% level of significance.

Dry matter

Dry matter (%) was significantly influenced by different varieties in all observations under the study. Higher dry matter (%) was observed from V_2-BARI Puishak-2 (6.13%) while lower dry matter (%) was observed from V_1-BARI Puishak-1 (5.03%). There was significant difference found among the two Indian spinach varieties in case of dry matter content (Table 1). Significant variation was found due to the different treatments on dry matter (%) of Indian spinach. The highest (6.79%) dry matter (%) was recorded from T_5 and the lowest (4.54%) dry matter (%) was observed from T_1 (Table 2). Combine effect of different treatments and varieties on dry matter (%) showed highly significant differences. The highest (7.25%) dry matter (%) was recorded from V_2T_5. V_1T_1 gave the lowest (4.16%) dry matter percentage (Table 6).

Table 5. Effect of interaction of variety and treatment on number of branches per plant at different days after sowing (DAS) characters of Indian spinach

Treatments combinations		Number of branches per plant at different days after sowing (DAS)			
		40	60	80	100
V1:BARI Puishak-1	T_1 (Control)	1.00	4.20	5.40	4.80
	T_2 (10 ton/ha bioslurry)	6.20	9.40	10.60	10.40
	T_3 (15 ton/ha bioslurry)	2.40	5.80	6.80	12.00
	T_4 (20 ton/ha bioslurry)	5.40	8.80	10.00	10.60
	T_5 (Recommended NPKS)	7.40	10.40	11.60	11.20
V2:BARI Puishak-2	T_1 (Control)	0.40	3.20	4.60	5.400
	T_2 (10 ton/ha bioslurry)	5.40	8.80	10.20	10.60
	T_3 (15 ton/ha bioslurry)	6.60	10.60	11.60	7.20
	T_4 (20 ton/ha bioslurry)	6.00	9.20	10.40	10.80
	T_5 (Recommended NPKS)	6.60	9.40	10.80	12.00
LSD(0.05)		1.16	1.51	1.49	1.52
LSD(0.01)		1.56	2.02	1.99	2.04
Level of sig.		**	**	**	**
CV (%)		19.09	14.73	12.63	12.45

** = Significant at 1% level of probability

Table 6. Effect of interaction of variety and different treatments of bioslurry on morphological characters of Indian spinach

Treatment combinations		Stem diameter (cm)	Leaf area (cm^2)	Dry matter (%)
V1:BARI Puishak-1	T_1 (Control)	1.22	86.02	4.16
	T_2 (10 ton/ha bioslurry)	1.44	58.04	5.13
	T_3 (15 ton/ha bioslurry)	1.13	137.60	5.11
	T_4 (20 ton/ha bioslurry)	1.52	164.60	5.31
	T_5 (Recommended NPKS)	1.31	174.10	6.33
V2:BARI Puishak-2	T_1 (Control)	1.37	82.72	4.92
	T_2 (10 ton/ha bioslurry)	1.52	144.20	5.58
	T_3 (15 ton/ha bioslurry)	1.27	143.80	5.71
	T_4 (20 ton/ha bioslurry)	1.69	214.20	7.20
	T_5 (Recommended NPKS)	1.43	221.70	7.25
LSD(0.05)		0.09	3.41	0.17
LSD(0.01)		0.12	4.57	0.22
Level of sig.		ns	**	**
CV (%)		5.21	1.86	2.32

** = Significant at 1% level of probability, ns= Non-significant

Table 7. Effect of variety on nutrient contents of Indian spinach

Variety	%P	%K	%Ca	% S	% Na
V1: BARI Puishak-1	0.95	3.27	0.93	0.51	0.30
V2: BARI Puishak-2	1.08	4.17	0.94	0.57	0.27
LSD(0.05)	0.02	0.05	0.02	0.02	0.02
LSD(0.01)	0.02	0.07	0.02	0.02	0.02
Level of sig.	**	**	ns	**	**
CV (%)	0.48	2.45	2.98	4.22	5.05

** = Significant at 1% level of probability, ns= Non significant.

Table 8. Effect of different treatments of bioslurry on nutrient contents of Indian spinach

Treatments	%P	%K	%Ca	% S	% Na
T_1 (Control)	0.59	2.88	0.72	0.37	0.21
T_2 (10 ton/ha bioslurry)	1.02	3.25	0.84	0.50	0.22
T_3 (15 ton/ha bioslurry)	0.98	3.79	0.96	0.52	0.30
T_4 (20 ton/ha bioslurry)	1.11	4.04	0.99	0.62	0.35
T_5 (Recommended NPKS)	1.39	4.65	1.17	0.70	0.35
LSD(0.05)	0.03	0.08	0.03	0.04	0.03
LSD(0.01)	0.04	0.11	0.04	0.04	0.04
Level of sig.	**	**	**	**	**
CV (%)	0.48	2.45	2.98	4.22	5.05

** = Significant at 1% level of probability

Table 9. Combine effects of variety and treatments on nutrient contents of Indian spinach

Treatments combination		%P	%K	%Ca	% S	% Na
V1:BARI Puishak-1	T_1 (Control)	0.28	1.98	0.54	0.42	0.21
	T_2 (10 ton/ha bioslurry)	1.15	3.61	0.90	0.47	0.27
	T_3 (15 ton/ha bioslurry)	1.19	3.21	1.05	0.53	0.37
	T_4 (20 ton/ha bioslurry)	0.93	3.89	1.44	0.59	0.40
	T_5 (Recommended NPKS)	1.22	3.67	0.72	0.58	0.27
V2:BARI Puishak-2	T_1 (Control)	0.89	3.77	0.90	0.32	0.22
	T_2 (10 ton/ha bioslurry)	0.88	2.88	0.78	0.53	0.17
	T_3 (15 ton/ha bioslurry)	0.77	4.38	0.87	0.51	0.23
	T_4 (20 ton/ha bioslurry)	1.29	4.20	0.54	0.65	0.30
	T_5 (Recommended NPKS)	1.55	5.63	1.62	0.82	0.43
LSD(0.05)		0.04	0.11	0.04	0.04	0.04
LSD(0.01)		0.05	0.15	0.05	0.0	0.05
Level of sig.		**	**	**	**	**
CV (%)		0.48	2.45	2.98	4.22	5.05

** = Significant at 1% level of probability

Phosphorus content

Phosphorus content was significantly influenced by different varieties in all observations under the study. Higher phosphorus content was observed from V_2-BARI Puishak-2 (1.08%) while lower phosphorus content was observed from V_1-BARI Puishak-1 (0.95%). There was significant difference found among the two Indian spinach varieties in case of phosphorus content (Table 7). Significant variation was found due to the different treatments on phosphorus content of Indian spinach. The highest (1.39%) phosphorus content was recorded from T_5 and the lowest (0.59%) phosphorus content was observed from T_1 (Table 8). Combine effect of different treatments and varieties on phosphorus content showed highly significant differences. The highest (1.55%) phosphorus content was recorded from V_2T_5. V_1T_1 gave the lowest (0.28%) phosphorus content (Table 9).

Potassium content

Potassium content was significantly influenced by different varieties in all observations under the study (Table 7). Higher potassium content was observed from V_2-BARI Puishak-2 (4.17%) while lower potassium content was observed from V_1-BARI Puishak-1 (3.27%). There was significant difference found among the two Indian spinach varieties in case of potassium content (Table 7). Significant variation was found due to the different treatments on potassium content of Indian spinach (Table 8). The highest (4.65%) potassium content was recorded from T_5 and the lowest (2.88%) potassium content was observed from T_1 (Table 8). Combine effect of different treatments and varieties on potassium content showed highly significant differences (Table 9). The highest (5.63%) potassium content was recorded from V_2T_5. V_1T_1 gave the lowest (1.98%) potassium content (Table 9).

Sulphur content

Sulphur content was significantly influenced by different varieties in all observations under the study. Higher sulphur content was observed from V_2-BARI Puishak-2 (0.57%) while lower sulphur content was observed from V_1-BARI Puishak-1 (0.51%). There was significant difference found among the two Indian spinach varieties in case of sulphur content (Table 7). Significant variation was found due to the different treatments on sulphur content of Indian spinach. The highest (0.70%) sulphur content was recorded from T_5 and the lowest (0.37%) sulphur content was observed from T_1 (Table 8). Combine effect of different treatments and varieties on sulphur content showed highly significant differences. The highest (0.82%) sulphur content was recorded from V_2T_5. V_2T_1 gave the lowest (0.32%) sulphur content (Table 9).

Calcium content

Calcium content was similar by different varieties in all observations under the study. Higher calcium content was observed from V_2-BARI Puishak-2 (0.94%) while lower calcium content was observed from V_1-BARI Puishak-1 (0.93%). There was no significant difference found among the two Indian spinach varieties in case of calcium content (Table 7). Significant variation was found due to the different treatments on calcium content of Indian spinach. The highest (1.17%) calcium content was recorded from T_5 and the lowest (0.72%) calcium content was observed from T_1 (Table 8). Combine effect of different treatments and varieties on calcium content showed highly significant differences. The highest (1.62%) calcium content was recorded from V_2T_5. V_1T_1 gave the lowest (0.54%) calcium content (Table 9).

Sodium content

Sodium content was significantly influenced by different varieties in all observations under the study. Higher sodium content was observed from V_1-BARI Puishak-1 (0.30%) while lower sodium content was observed from V_2-BARI Puishak-2 (0.27%). There was sodium difference found among the two Indian spinach varieties in case of sodium content (Table 7). Significant variation was found due to the different treatments on sodium content of Indian spinach. The highest (1.60%) sodium content was recorded from T_5 and the lowest (1.29%) sodium content was observed from T_1 (Table 8). Combine effect of different treatments and varieties on sodium content showed highly significant differences. The highest (0.43%) sodium content was recorded from V_2T_5. V_2T_2 gave the lowest (0.17%) sodium content (Table 9).

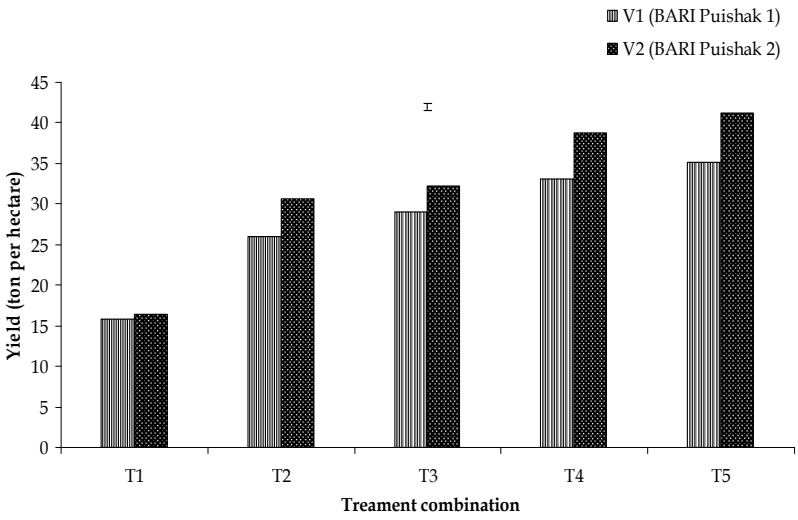

Fig. 2. Combine effect of variety and treatment on yield (t/ha)of Indian spinach.V_1= BARI Puishak-1, V_2= BARI Puishak-2, T_1= control, T2= 10 ton/ha bioslurry, T3= 15 ton/ha bioslurry, T4= 20 ton/ha bioslurry, T5= Recommended NPKS. Vertical bar represents LSD at 5% level of significance.

Yield

Yield per plant was significantly influenced by different varieties in all observations under the study. Higher yield per hectare (40.73 ton) was observed from V_2-BARI Puishak-2 while lower yield per hectare (38.76 ton) was observed from V_1-BARI Puishak-1 (Table 1). Significant variation was found due to the different treatments on yield per plant of Indian spinach. The highest yield per hectare (51.37 ton) was recorded from T_5 and the lowest yield per hectare (20.45 ton) was observed from T_1 (Table 2). Combine effect of different treatments and varieties on yield per plant showed highly significant differences. The highest yield per hectare (55.01 ton) was recorded from V_2T_5. V_2T_1 provides the lowest yield (21.04 ton) per hectare (Fig. 2).

Discussion

Vine length is one of the important growth contributing characters for Indian spinach plant. Different fertilizers influenced the vegetative growth of plant and the ultimate results were the longest plant as compared to control. There was significant difference among different fertilizers for vine length of Indian spinach. During the period of plant growth the highest vine length was found with recommended fertilizers and the lowest was found when Indian spinach was produced without any fertilizers. Similar results were reported by several authors (Hamid *et al.,* 1989; Islam *et al.,* 1984). Hamid *et al.,* (1989) reported for the highest plant (85.25 cm) by applying the highest dose of nitrogen (250 kg N/ha). In this experiment second highest vine length was found with bioslurry treatment 20 ton per hectare (Islam 2006) reported that use of bioslurry promote plant height. Plant height was also influenced by plant species. Significant difference was found due to the combined effect of different fertilizers and plant species at different days after sowing. In case of all the treatment combinations, it was observed that application of recommended inorganic fertilizers on BARI Puishak-2 gave longest vine length and shortest vine length was found in BARI Puishak-1 produced without fertilizers. Since bioslurry contains sufficient amount of nitrogen, potassium and phosphorous so this could be the response behind the growth and yield of Indian spinach. In this experiment second longest vine length was observed from bioslurry 20 ton per hectare on BARI Puishak-2. Brahma *et al.* (2002) conducted a field experiment for two years at Assam Agricultural University in India during Rabi season to study the effect of nitrogen, phosphorous and potassium on the growth and yield of Indian spinach. They found that growth and yield of Indian spinach was highly improved with the increasing level of potassium.

Good foliage indicates higher growth, development and productivity of a plant. In the present study, number of leaves was significantly influenced by different fertilizers applied. The highest leaf number was found in recommended inorganic fertilizers and the lowest leaf number was found in control. Brahma *et al.* (2002) reported that nitrogen increases number of leaves per plant. The second highest leaf number was observed from bioslurry 20 ton per hectare on BARI Puishak-2. Bioslurry contains sufficient amount of nitrogen. Bachmann *et al.* (2011) reported bioslurry as a phosphorus and nitrogen source. Significant variation in number of leaves was observed due to the effect of varieties. The combined effect of treatments and plant species significantly influenced the number of leaves per plant at different DAS.

No significant variation in branch number was found due to varieties at 40 DAS, 60 DAS, 80 DAS and 100 DAS. The highest number branch was found in well recommended chemical fertilizer and similar result was

also found in 20 ton bioslurry per hectare while the lowest was found in the control. Tisselli (1999) reported that maximum rates of organic manure (usually poultry manure) and NPK recommended in 1998 for using in lettuce crops in Emilia-Romagna and Italy. Trials showed that a combination of bioslurry gave higher yields of marketable heads, fewer rejects and a better average weight/head similar to chemical fertilizer. Significant difference found due to verities in case of stem diameter. BARI Puishak-1 performed better in respect of stem diameter. The highest stem diameter was observed from 20 ton bioslurry per hectare while control gave the lowest stem diameter. There was no significant difference in interaction effect in this case. Agnes *et al.* (2012) concluded that root and shoot diameter increase with the use of bioslurry.

Statistically significant variation was found due to different treatments on leaf area of Indian spinach. The highest leaf area was found in recommended chemical fertilizer and the lowest leaf length was found in control. Leaf area per plant had no significant variation for the different plant species. The highest leaf area was recorded from BARI Puishak-2 and the lowest leaf length was found from BARI Puishak-1. The combined effect of different fertilizers and plant variety influenced the leaf area of Indian spinach. The highest leaf area was found from BARI Puishak-2 with recommended chemical fertilizer followed by 20 ton bioslurry per hectare and the lowest leaf area was found in BARI Puishak-1 without any fertilizers. Brahma *et al.* (2002) reported that nitrogen increases size of leaf area including length and breadth.

Significant variation was found due to different fertilizers on dry mater percent of stem of Indian spinach. The highest dry mater percent of stem was found in recommended inorganic fertilizers and the lowest dry mater percent of leaf was found in control. Dry mater percent of stem showed no significant variation for the different plant species. Higher dry mater percent of leaf was recorded from BARI Puishak-2 and lower dry mater percent of stem was found from BARI Puishak-1. BARI Puishak-2 has higher ability of nutrient uptaking from soil. The combined effect of different fertilizers and plant species influenced the dry mater percent of stem of Indian spinach. Higher dry mater percent of stem was found from BARI Puishak-2 with recommended fertilizers and lower dry mater percent of stem was found in BARI Puishak-1 with no fertilizer.

The yield is the main factor for Indian spinach production. The highest yield per pot was found from recommended inorganic fertilizers and the lowest yield per pot was recorded from control pot. It might be due to the fact that nitrogen might have encouraged vegetative growth of Indian spinach plant and as a result photosynthesis occurred at higher rate in the leaves producing more yield (Rahman *et al.* 1985). The yield of Indian spinach per plant was influenced by different plant species. The highest yield per pot was recorded from BARI Puishak-2 and the lowest yield per plant was obtained from the BARI Puishak-2. Rahman *et al.* (1985) studied Indian spinach and reported that the highest yield (62.89 ton/ha) was obtained from BARI Puishak-2 when the highest dose of nitrogenous fertilizer was applied following closest spacing. The combined effect of different fertilizers and plant species significantly influenced the yield of Indian spinach per pot. Second highest yield per pot was recorded from BARI Puishak-2 with 20 ton bioslurry per hectare, while BARI Puishak-2 without any fertilizers gave the lowest yield per plant.

Significant variation was observed from variety on nutrient characters of Indian spinach. Phosphorus percentage, potassium percentage, calcium percentage, sulphur percentage, sodium percentage were maximum in BARI Puishak-2 while minimum in BARI Puishak-1. Significant variation was observed from treatments on nutrient characters of Indian spinach. Phosphorus percentage, potassium percentage, calcium percentage, sulphur percentage, sodium percentage were maximum in recommended chemical fertilizers while minimum in control. Twenty-ton bioslurry per hectare gave the second highest result in all of the nutrient components of Indian spinach. There were significant variation also found on combined effect of varieties and treatments. Maximum phosphorus percentage, potassium percentage, calcium percentage, sulphur percentage and sodium percentage were observed from BARI Puishak-2 with recommended chemical fertilizers while minimum amount of all those components were found from BARI Puishak-1 with control. Hossain *et al.* (2013), Majumder (2006), Raj (2006) agreed with the nutrient composition increase within the plant by application of bioslurry.

The yield of Indian spinach per hectare was high significantly influenced by different fertilizers. The highest yield per hectare was found from recommended inorganic fertilizers while the lowest was recorded from control pot. The yield per hectare increased with the increasing levels of nitrogen as stated by different workers Brahma *et al., (*2000), Rashid *et al.,* (1981), Islam *et al., (*1984), Rahman *et al., (*1985), Aditya *et al., (*1995). Hamid *et al.,* (1986) reported that the highest yield (79.34 ton/ha) was obtained by applying the highest dose of nitrogen (250 kg N/ha). Increasing amount of bioslurry doses provide the necessary amount of nitrogen needed for plant could be the reason behind increasing rate of Indian spinach yield. Yield per hectare varied due to the different verities. The highest yield of Indian spinach was obtained from BARI Puishak-2 while the lowest was recorded from Indian BARI Puishak-1. The combined effect of different fertilizers and plant species significantly influenced the yield of Indian spinach per hectare. The highest yield per hectare was recorded from BARI Puishak-2 with recommended inorganic fertilizers, while BARI Puishak-2 with 20 ton bioslurry per hectare give second height yield per

hectare which is quite similar with the maximum yield per hectare. BARI Puishak-1 with no fertilizers gave the lowest yield per hectare. Rahman *et al.* (1985) studied Indian spinach and reported that the highest yield of greens (62.89 ton/ha) was obtained from the closest spacing when the highest dose of nitrogenous fertilizer was applied. Hossain *et al.* (2013) studied growth response of Indian spinach to biogas plant residues and proved that 40ton bioslurry per hectare give satisfactory vegetative growth and yield.

From the above discussion it is clear that growth, yield and nutritional status of Indian spinach largely depend upon the application of bioslurry, chemical fertilizers and varieties.

Conclusion

Amending soils with bioslurry enhanced the vegetative growth and nutritional status of Indian spinach. Among the doses of tested bioslurry, it can be concluded that 20 ton ha^{-1} proved to be the best in enhancing the vegetative growth of Indian spinach. More research on testing different rates with BARI Puishak-2 under different soil agro-ecological zone conditions may be beneficial in coming up with specific rates for the different production area.

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