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Effect of foliar application of chitosan on growth and yield in indian spinach

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Abstract: A pot experiment was conducted at the pot yard of Bangladesh Institute of Nuclear Agriculture, Mymensingh during the period from April to June 2011 to investigate the effect of Chitosan application on morphological characters, growth and economic yield in Indian spinach. The experiment comprised five levels of Chitosan concentrations *viz*., 0 (control), 25, 50, 75 and 100 ppm. The Chitosan was sprayed two times of 15 and 25 days after sowing. The experiment was laid out in a completely randomized design with four replications. Application of Chitosan had a profound influence on morphological characters such as plant height, branch and leaf number, physiological characters such as specific leaf weight (SLW), chlorophyll content in leaves and nitrate reductase activity (NRA) in leaves and yield characters such leaf area (LA), leaf and stem fresh weight as well as total fresh weight. Plant height and leaf number plant^{-1} increased with increasing concentration of Chitosan whereas branch number, LA, leaf and stem fresh weight as well as total fresh weight increased till 75 ppm followed by a decline with higher concentration. The highest plant height and leaf number plant^{-1}, chlorophyll and NRA were recorded in 100 ppm followed by 75 ppm Chitosan. The highest number of branches plant^{-1}, LA plant^{-1}, SLW, leaf and stem fresh weight as well as total fresh weight was observed in 75 ppm followed by 100 ppm Chitosan. In contrast, control plants showed the lowest of the above studied parameters. However, the economic parts of Indian spinach, leaf and stem fresh weight as well as total fresh weight was the highest when Chitosan was sprayed @ 75 ppm. These results indicate that application of Chitosan @ 75 ppm is optimum for maximizing plant growth and development of Indian spinach.
Key words: Indian spinach, Chitosan growth promoter, vegetable yield

Introduction

Now-a-days, Indian spinach (*Basella alba* L.) is the most popular and nutritious leafy vegetable crops in Bangladesh. It is widely grown not only in Bangladesh but also in tropical Asia and Africa (Bose *et al*., 2008). It is cultivated in almost all home gardens and also in the field for its adaptability to a wide range of soil and climate in Bangladesh. The nutritive value of the young shoots and leaves is very high in terms of salt and vitamins. According to Bose *et al.* (2008), the plant is reported to contain protein 1.9%, carbohydrate 3.0%, iron 1.4 mg/100g, vitamin A 3250 IU/100g, calcium 0.15%. With the increase of population, the demand of Indian spinach in our country is increasing day by day. By producing more Indian spinach we can earn a considerable amount of foreign exchange through exporting it. So, by increasing Indian spinach producing area, we can fulfil our demand but due to limitations of lands, it is not possible. The most logical way to increase the total production at the national level from our limited land resources is to increase yield per unit area and increase Indian spinach cropping intensity through growing in summer.

However, the yield performance of Indian spinach is very poor in Bangladesh, only 10-13 tons ha^{-1} (Hoque, 2005). So, it is urgent to increase yield by proper management and cultural practices. Plant growth regulators are one of the most important factors for increasing higher yield in leafy vegetables. Application of growth regulators has good management effect on growth and yield of field crops. Hormones regulate physiological process and synthetic growth regulators may enhance growth and development of field crops thereby increased total dry mass of a field crop (Das and Das, 1996; Abd-el-Fattah, 1997; Chibu *et al*., 2000; Dakua, 2002; Rahman, 2004; Islam, 2007; Cho *et al*., 2008).

Application of plant growth regulator seems to be one of the important practices in view of convenience, cost and labour efficiency. Recently, there has been global realization of the important role of PGRs in agriculture for better growth and yield of crops. Developed countries like Japan, China, Poland, South Korea etc. have long been using PGRs to increase crop yield. Like other crop plants, the physiological mechanisms of Indian spinach growth are hormonally mediated. Additional supply of plant growth regulators (PGRs) control growth and yield in plants. Chitosan, a new plant growth promoter like GA_3 that may have many uses to modify the growth, yield and yield attributes of plant. Chitosan derived from the shell of quick growing sea shrimp. Application of Chitosan enhances growth and yield attributes in rice and soybean (Chibu *et al*., 2002), in sunflower (Cho *et al*., 2008), in radish, barly and wheat (Chibu *et al*., 2000) and in maize (YueDong *et al*., 2001). Research works with Chitosan on growth, yield attributes and yield of Indian spinach are still absent. Considering the above facts, the present research work was undertaken to study the effect of Chitosan on growth, yield attributes and economic yield in Indian spinach under Bangladesh conditions.

Materials and Methods

A pot experiments was carried out at the pot-yard of Bangladesh Institute of Nuclear Agriculture, Mymensingh ($24^0$75″ N and $90^0$50″ E), Bangladesh during 10 April to 25 June 2011. The soil of the experiment was sandy loam having a total nitrogen 0.06%, organic matter 1.15%, available phosphorus 18.5 ppm, exchangeable potassium 0.28 meq%, sulphur 18 ppm and pH 6.8. The experiment comprised of five concentrations of Chitosan *viz.*, 0, 25, 50, 75 and 100 ppm were applied at 15 and 25 days after sowing. A most commonly local cultivar (green stem and leaves) was undertaken for planting material. The soil was thoroughly mixed with given amounts of urea, triple super phosphate and muriate of potash, gypsum and cowdung at the rate of 10.18, 4.36, 4.27, 2.18 and 150 g pot^{-1}corresponding to 200, 110, 100, 40 and 10000 kg ha^{-1}, respectively. Total amount of TSP, MP, gypsum and cowdung were applied as basal dose during soil

preparation. Half of urea was applied as top dress at 21 DAS and rest half was applied at 45 DAS. The pots of the experiment were filled with 12 kg of soils. The experiment was laid out with completely randomized design with four replications. Three seeds were sown in each pot on 10 April 2011. Finally, they were thinned to one seedling after 15 days of sowing. The formulation of Chitosan was water-soluble solution. The supplied stock was 25000 ppm. Then it was prepared 25, 50, 75 and 100 ppm for 1L water and spraying was done on Indian spinach plants at afternoon by using a hand sprayer. Weeding and soil loosening were done as and when necessary. Water was supplied as and when needed to ensure sufficient moisture for the normal growth of the plants. No plant protection measures were taken due to no insect pest and leaf diseases was observed. The first harvest was done at 50 days after sowing (DAS) and second harvest was done at 80 DAS. At each harvest stem was cut at 5 cm above the ground. At each harvest, the morphological, biochemical and yield were recorded. Leaf chlorophyll was determined following the method of Yoshida *et al.* (1976). Leaf area was measured by automatic leaf area meter (Model: LI 3000 USA). The specific leaf weight was determined as follows: Leaf area ÷ leaf fresh weight. The collected data were analyzed statistically using the computer package programme, MSTAT-C and the mean differences were adjudged by Duncan's Multiple Range.

Results and Discussion

The effect of different concentrations of Chitosan on plant height, number of branches and leaves plant^{-1} at 50 and 80 days after sowing (DAS) of Indian spinach was significant (Table 1). Result revealed that plant height, number of branches and leaves plant^{-1} was greater in Chitosan applied plants than control plants. These results indicate that foliar application of Chitosan had influence on plant growth. However, plant height and number of leaves plant^{-1} increased with increasing concentration of Chitosan except 100 ppm for branch number. The highest plant height and number of leaves plant^{-1} was recorded at 100 ppm Chitosan application both at 50 and 80 DAS whereas the highest number of branches plant^{-1} was observed in 75 ppm Chitosan. In contrast, control plant maintained the shortest plant, produced the lowest number of branches and leaves plant^{-1} at all growth stages. Similar result was also reported by No *et al.* (2003) and JiaAn *et al.* (2002), respectively, in soybean and rice where Chitosan increased plant height, branch and leaf number over control.

Table 1. Effect of different concentration of Chitosan on plant height and branch production in Indian spinach

Concentration (ppm)	Plant height (cm) at days after sowing of		Number of branches plant^{-1} at days after sowing of		Number of leaves plant^{-1} at days after sowing of	
	50	80	50	80	50	80
0	27.7 b	53.0 c	0.50 c	3.00 b	15.5 c	32.2 c
25	26.5 b	53.8 c	0.50 c	3.15 b	17.0 b	33.3 bc
50	31.5 a	56.0 c	1.30 b	3.25 b	18.8 a	35.8 ab
75	32.5 a	67.0 b	1.50 a	3.75 a	19.8 a	37.0 a
100	34.2 a	71.2 a	1.50 a	3.55 a	20.0 a	38.3 a
F-test	**	**	**	**	**	**
CV (%)	5.62	3.79	11.43	5.75	5.40	6.12

In a column figures having the same letter (s) do not differ significantly at P ≤0.05, * indicates significant at 1% levels of probability

Table 2. Effect of different concentration of Chitosan on leaf area development and physiological traits in Indian spinach

Concentration (ppm)	Leaf area plant^{-1} (cm^2) at days after sowing of		Specific leaf weight (cm^2 g^{-1})	Chlorophyll (mg g^{-1} fw)	Nitrate reductase (µmol NO_2^- g^{-1} fw)
	50	80			
0	524.2 d	1000 b	6.57 c	2.240 b	6.22 b
25	594.0 c	1069 ab	7.07 ab	2.300 ab	6.30 b
50	599.3 c	1091 ab	7.11 ab	2.420 a	6.71 a
75	716.0 a	1142 a	7.27 a	2.400 ab	6.66 a
100	648.0 b	1098 ab	6.88 b	2.460 a	6.74 a
F-test	**	*	**	*	**
CV (%)	4.10	3.25	3.26	4.45	3.11

In a column figures having the same letter (s) do not differ significantly at P ≤0.05, *, ** indicates significant at 5% and 1% levels of probability, respectively;

The leaf area (LA) plant^{-1}, specific leaf weight (SLW), chlorophyll content and nitrate reductase activity (NRA) in leaves were significantly influenced by the application of Chitosan (Table 2). Results revealed that LA and SLW increased with increasing concentration of Chitosan till 75 ppm followed by a decline. These results indicate that application of 75 ppm Chitosan at early growth stage is optimum for leaf growth and development of Indian spinach. The leaf chlorophyll and NRA increased with increasing concentration of Chitosan. But there was non-significant different in chlorophyll and NRA among the concentrations of 50, 75 and 100 ppm. In contrast, the lowest LA, SLW, chlorophyll content and NRA in leaves was observed in control plants. These results indicate that foliar application of Chitosan on Indian spinach at early growth stages stimulates biochemical activity thereby increased LA and leaf fresh weight. Chibu *et al.* (2002) applied Chitosan on soybean and found that leaf area increased in Chitosan applied plants than control plants which support the present result. No *et al.* (2003) reported that application of Chitosan increased carbohydrates in soybean leaves. Similar phenomenon may be occurred in the present experiment and thereby increased SLW of Indian spinach in Chitosan applied plants. The highest SLW was recorded in 75 ppm Chitosan (7.27 cm^2 g^{-1}) and the lowest was recorded in control plants (6.57 cm^2 g^{-1}).

Table 3. Effect of different concentration of Chitosan on leaf and stem fresh weight in Indian spinach

Concentration (ppm)	Leaf fresh weight plant^{-1} (g) at days after sowing of			Stem fresh weight plant^{-1} (g) at days after sowing of			Gross total fresh weight plant^{-1} (g)
	50	80	Total	50	80	Total	
0	75.2 e	117.5 c	192.7 d	175.0 b	250.0 b	425.0 c	617.7 d
25	85.0 d	126.2 bc	211.2 c	180.0 b	268.8 ab	448.8 bc	660.0 c
50	90.0 c	138.5 ab	228.5 bc	193.8 ab	275.0 ab	468.8 ab	697.3 b
75	102.5 a	149.2 a	251.7 a	211.2 a	288.0 a	499.2 a	750.9 a
100	96.7 b	137.5 ab	234.2 ab	201.2 a	278.0 a	479.2 ab	713.4 ab
F-test	**	**	**	**	*	**	**
CV (%)	3.61	6.82	5.47	6.97	5.89	4.49	5.59

In a column figures having the same letter (s) do not differ significantly at P ≤0.05, *, ** indicates significant at 5% and 1% levels of probability, respectively

The application of Chitosan at different concentrations on leaf, stem and total fresh weight plant^{-1} both at 50 and 80 DAS was significant (Table 3). The leaf, stem and total fresh weight plant^{-1} was greater at 80 DAS than in 50 DAS due to increased plant height and branch number. Results revealed that leaf and stem fresh weight as well as total fresh weight plant^{-1} increased with increasing Chitosan concentration till 75 ppm followed by a slightly decline both at 50 and 80 DAS. The highest leaf, stem and total fresh weight plant^{-1} was recorded in 75 ppm followed by 100 ppm Chitosan with same statistical rank. Control plants produced the lowest leaf, stem and total fresh weight over growth period due to shorter plant with fewer number of leaves plant^{-1}. Higher leaf, stem and total fresh weight with 75 ppm Chitosan was possibly due to increased branch number and SLW (Tables 1, 2). These results are supported by Chibu *et al.* (2000) who reported that application of Chitosan increased TDM over control in soybean and rice.

In conclusion, it can be said that foliar application of Chitosan at early growth stage enhance plant growth and development which resulted increased economic yield in Indian spinach. Among the concentrations, 75 ppm had superiority for plant growth thereby economic yield over 25, 50 and 100 ppm. Therefore, foliar application of Chitosan at 75 ppm may be recommended for Indian spinach cultivation after few more field trials.

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