Ann. Bangladesh Agric. (2015) 19(2) : 11-21 ISSN 1025-482X

RESPONSE OF STEM AMARANTH TO DIFFERENT LEVELS OF NITROGEN, PHOSPHORUS AND POTASSIUM

A. U. Ahammed, M. M. Rahman* and A. J. M. S. Karim

Abstract

The experiment was conducted at the Horticulture Research field of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) during March 2008 to July 2008 to determine the optimum rate of N, P and K for better stem growth and seed yield of amaranth. The amaranth genotype SA040 was used as test crop for the study. The experiment was laid out in randomized complete block design with three replications having five levels of N (0, 50, 100, 150 and 200 kg ha^{-1}), five levels of P (0, 25, 50, 75 and 100 kg ha^{-1}) and five levels of K (0, 25, 50, 75 and 100 kg ha^{-1}). The highest stem yield (105.51 t ha^{-1}), was yield attributes, were found with the application of 150 kg N, 25 kg P and 50 kg K ha^{-1}. Maximum seed yield (4.66 t ha^{-1}) was found by the application of 100 kg N, 50 kg P and 50 kg K ha^{-1}. The response regression curve suggest that 165.5 kg N, 64.4 kg P and 52.04 kg K ha^{-1} and 168 kg N, 55 kg P, 58.5 kg K ha^{-1} are optimum for higher stem and seed yield of amaranth, respectively. A positive linear relationship between stem weight /plant and stem diameter, and a negative linear relationship between dry matter content with the stem yield were observed.

Keywords: Amaranth, phosphorus, nitrogen, potassium, stem and seed yield

Introduction

Stem amaranth (*Amaranthus tricolor* L.) belongs to the genus *Amaranthus* of the family Amaranthaceae and is locally known as danta. Danta is a nutritious vegetable which is a rich source of protein, minerals, vitamin A, vitamin C and also diet able fiber (Muthukrishnan and Irulappan, 1986). In Bangladesh, it is a major vegetable grown during summer season when vegetable is scarce and is produced only 38% of the total requirements. To meet up the daily vegetable requirement, during summer season, stem amaranth can play a vital role in the increase of the total vegetable production in the country. According to BBS (2011), the amaranth is being cultivated in an aresa 10463.56 ha with a total production 67358 tons and the average yield is only 6.88 t ha^{-1}, which is low compared to other growing country.

Amaranth requires high soil fertility, since their mineral uptake is very high. They respond to N, P and K and particularly to high K. The growers obtain good results from higher application (50 t ha^{-1}) of fresh or partly decomposed town refuse where fertilizer is expensive and manure is not available (Shanmugavelu, 1989). Being a C_4 plant danta has more efficiency of nitrogen utilization and photosynthesis (Magomedov *et al.,* 1997)

Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur-1706, Bangladesh. *Corresponding author: M. M. Rahman

along with the seed yield potential of more than 5.0 t ha^{-1}. The crop has a wide adaptability and also shows good response to production inputs like nitrogen (Bhaskar *et al.,* 1996; Joshi and Rana, 1991). Nitrogen is an essential and important determinant for growth and development of crop plants (Tanaka *et al.,* 1984). Phosphorous application increases the diameter of stem and root and number of leaves per plant. Potassium increases water holding capacity of plant tissue, succulence of vegetables and retains good condition for longer period

Use of fertilizers to maximize yield of any crop is a unanimous recommendation all over the world. However, right type, right time, right amount and right method of fertilizer application should be ensured to get the maximum benefit. The vegetable growers in Bangladesh are using various fertilizers for amaranth without following proper dose; precise recommendation based on systematic research is not yet available. Again, information on interaction effects of three essential elements (N, P and K) on stem and seed productivity of amaranth is still scant. This study was initiated to analyze the stem and seed yield response of amaranth at different levels of nitrogen, phosphorus and potassium.

Materials and Methods

The experiment was conducted at the experimental field of Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh during March 2008 to July 2008. The experimental field belongs to AEZ 28 (Madhupur tract) and Salna series of Shallow Red Brown soil (Brammer, 1971; Saheed, 1984). The soil contains 1.34% organic matter and pH 5.4. The total N, available P and exchangeable K contents were 0.063%, 22.00 ppm and 0.33 meq/100 g soils respectively. There were fifteen treatments combinations comprising of five levels of N (0, 50, 100, 150 and 200 kg ha^{-1}), five levels of P (0, 25, 50, 75 and 100 kg P/ha) and five levels of K (0, 25, 50, 75 and 100 kg K/ha). Sulphur (S) was used as blanket dose @ 4 kg ha^{-1}. Cow dung (CD) was applied at the rate of 10 t ha^{-1} and 5t ha^{-1}. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The unit plot size was 1.5m x 1.5m. Sources of N, P and K were urea, triple super phosphate (TSP) and muriate of potash (MoP) respectively. The full dose of cow dung TSP and MoP were applied as basal dose during final land preparation. Urea was applied in three equal installments as top dressing at 15, 25 and 35 days after sowing (DAS). Amaranth genotype SA040 was used as plant material for the study. This genotype was selected previously for its higher stem diameter and yield (Ahammed *et al*., 2013). Seeds were sown continuously on 27 March 2008 between rows about 30 cm apart. Seedlings were thinned maintaining a spacing 30 cm x 10 cm after 15 days of sowing. Intercultural operations were done following Rashid (1999). The half of the crop of a plot was harvested when it started flowering for assessing stem yield and its related parameters. The reaming crop plant was harvested for seed yield when the inflorescences are begun to drying. Data were recorded during harvesting time on plant height (cm), leaves/plant, stem diameter (mm), leaf weight/plant (g), stem weight/plant (g), leaf - stem ratio, stem yield (t ha^{-1}), fibre (%), dry matter (%), days to first flowering, days to 50% flowering, seed yield/plant, seed yield (t/ha) and 1000 seed weight (g) during seed harvesting. Recorded data on different parameters were analyzed statistically and the means were separated by DMRT (Gomez and Gomez, 1984) at 5% level of probability. The yield response equation used to quantify the added nutrients giving the maximum yield of crop was $Y= a + bx + cx^2$.

Results and Discussion

Plant height

Plant height was significantly influenced by different fertilizer treatment combinations (Table 1). Maximum plant height (105.00 cm) was observed in the treatment T_3 ($N_{100}P_{25}K_{50}$) which was closely followed by the treatment T_4 (N_{150} $P_{25}K_{50}$) and minimum plant height (83.22 cm) was recorded in the treatment T_1 (N_0 $P_{25}K_{50}$) which was statistically similar to the treatment T_2 (N_{50} $P_{25}K_{50}$). No significant difference was observed between 200 kg and 100 kg N/ha in respect of plant height. Application of P and K at the rate of 25 and 50 kg ha^{-1} respectively also significantly increased plant height.

Chakhartrakan (2003) reported significant difference in plant height, stem diameter, number of leaves and plant fresh weight among different N treatments (0, 135.0, 187.5, 250.0 and 312 kg N ha^{-1}). The plant height in different treatments varied possibly due to applied treatments effect.

Leaves per plant

Significant variation was observed among different fertilizer treatments in respect of leaves per plant (Table 1). The highest number of leaves (25.11) was observed in the treatment T_4 ($N_{150}P_{25}K_{50}$) which was closely followed by T_3 ($N_{100}P_{25}K_{50}$) and T_5 ($N_{200}P_{25}K_{50}$) treatments. No significant difference was observed between 50,100,150 and 200 kg N/ha application in respect of leaves per plant. The lowest number of leaves (19.57) was found in the treatment T_1 (N_0 $P_{25}K_{50}$) which was statistically similar to T_2 (N_{50} $P_{25}K_{50}$), T_6 (N_{100} P_0K_{50}) and T_{14} (CD: 10 t ha^{-1}) treatments. Application of P and K at the rate of 25 and 50 kg ha^{-1} respectively also significantly produced maximum number of leaves.

Chakhartrakan (2003) reported significant differences in number of leaves, stem diameter, plant height and plant fresh weight among all treatments (0,125.0, 187.5, 250.0 and 312 kg N ha^{-1}). The number of leaves in different treatments varied possibly due to applied treatment effect.

Leaf weight per plant

Significant variation was observed among the fertilizer treatment in respect of leaf weight per plant (Table 1). Maximum leaf weight (80.83 g) per plant was recorded in the treatment T_4 ($N_{150}P_{25}K_{50}$) followed by T_3 (N_{100} $P_{25}K_{50}$) where as the lowest leaf weight per plant (54.14 g) was found in the treatment T_1 ($N_0P_{25}K_{50}$). Leaf weight per plant was increased by increasing application of N up to 150 kg/ha beyond which leaf yield declined (Table 1). Application of P and K at the rate of 25 and 50 kg/ha respectively also significantly produced highest leaf weight per plant beyond which it was decreased significantly. The leaf weight per plant varied possibly due to applied treatment.

Stem weight per plant

Stem weight per plant was significantly influenced by different fertilizer treatment combinations (Table 1). Different levels of N, P and K significantly influenced stem weight per plant. Maximum stem weight per plant (326.84 g) was recorded in the treatment T_4 ($N_{150}P_{25}K_{50}$) followed by T_3 (N_{100} $P_{25}K_{50}$) where as minimum stem weight per plant (234.55 g) was obtained in the treatment T_1 ($N_0P_{25}K_{50}$). Maximum stem weight per plant was recorded when N was applied at the rate of 150 kg N ha^{-1}. Application of P and K at the rate of 25 and 50 kg ha^{-1} respectively also produced maximum yield beyond which stem weight per plant decreased significantly.

Stem diameter

Significant variation was observed among different treatments in respect of stem diameter (Table 1). Maximum stem diameter (24.58 mm) was obtained in the treatment T_4 (N_{150} $P_{25}K_{50}$) followed by treatments T_3, T_5, T_7, T_8, T_9, T_{11}, T_{12} and T_{13} where as minimum stem diameter (18.34 mm) was recorded in the treatment T_1 (N_0 $P_{25}K_{50}$). Stem diameter increased up to 150 kg N ha^{-1} application. There was no significant difference between 100 and 200 kg N/ha application in respect of stem diameter. Stem diameters increased up to 25 kg P/ha and 50 kg K ha^{-1} respectively beyond which stem diameters decreased significantly.

Stem yield (t ha^{-1})

The stem yield varied significantly by different fertilizer treatment combinations (Fig. 1). The maximum stem yield (105.50 t/ha) was recorded in T_4 (N_{150} $P_{25}K_{50}$) treatment followed by T_3 (N_{100} $P_{25}K_{50}$) and T_5 (N_{200} $P_{25}K_{50}$) where as minimum stem yield (79.22 t

Table 1. Effect of N, P and K on plant height, leaves /plant, leaf weight, stem weight, leaf: stem ratio, stem diameter and stem yield (t ha^{-1}) of stem amaranth genotype

Treatment	Plant height (cm)	Leaves/ plant	Leaf weight / plant (g)	Stem weight / plant (g)	Leaf-stem ratio NS	Stem diameter (mm)
T_1	83.22c	19.57b	54.14c	234.55e	0.23	18.43d
T_2	91.11bc	19.84b	56.61bc	250.01de	0.23	19.44cd
T_3	105.00a	24.55a	73.77ab	316.29ab	0.23	24.09ab
T_4	104.78a	25.11a	80.83a	326.84a	0.25	24.58a
T_5	102.44ab	24.67a	72.23abc	310.99abc	0.23	23.45ab
T_6	98.67ab	20.11b	58.67bc	269.40b-e	0.22	22.34abc
T_7	101.67ab	23.55ab	71.67abc	307.21abc	0.23	23.33ab
T_8	101.67ab	22.78ab	70.34abc	307.96abc	0.23	23.10ab
T_9	101.34ab	22.42ab	66.26abc	305.47a-d	0.22	23.50ab
T_{10}	99.67ab	22.11ab	61.90bc	255.66cde	0.25	22.54abc
T_{11}	100.89ab	21.83ab	61.96bc	302.40a-d	0.21	22.96ab
T_{12}	99.67ab	21.66ab	60.38bc	283.39a-e	0.21	22.91ab
T_{13}	98.67ab	21.17ab	59.90bc	275.01a-e	0.22	22.85ab
T_{14}	96.22ab	20.21b	56.03bc	258.38cde	0.22	20.91bcd
T_{15}	98.33ab	21.33ab	57.75bc	265.92b-e	0.22	21.93abc
CV (%)	6.11	9.49	14.60	10.12	7.40	7.77

Means followed by same letter(s) in a column did not differ significantly from each other by DMRT at 5% level. NS indicates non-significant.

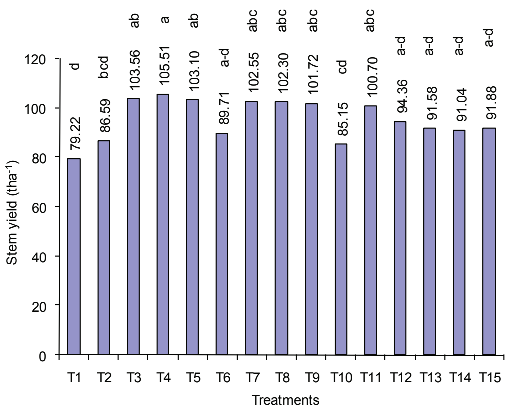

Fig. 1. Stem yield of stem amaranth as influenced by different levels of N, P and K

ha^{-1}) was obtained in T_1 (N_0 $P_{25}K_{50}$) treatment. Different levels of N, P and K significantly affected stem yield. Maximum stem yield was found when N was applied at the rate of 150 kg N ha^{-1} while it was found minimum in 0 kg N/ha. No significant difference was observed between 100 and 200 kg N ha^{-1} in respect of stem yield (t ha^{-1}). Application of P and K at the rate of 25 and 50 kg ha^{-1}, respectively also significantly produced maximum yield. Further increase in levels of P and K did not increase the stem yield. Heever *et al*. (2006) reported that nitrogen fertilizer was found to significantly increase the yield of vegetable amaranth with the highest rate of nitrogen (150 kg N ha^{-1}) application attaining the highest yield. The stem yield in different treatments varied possibly due to applied treatment effect.

$T_1= N_0\ P_{25}\ K_{50}$	$T_2= N_{50}\ P_{25}\ K_{50}$	$T_3= N_{100}\ P_{25}\ K_{50}$
$T_4= N_{150}\ P_{25}\ K_{50}$	$T_5= N_{200}\ P_{25}\ K_{50}$	$T_6= N_{100}\ P_0\ K_{50}$
$T_7= N_{100}\ P_{50}\ K_{50}$	$T_8= N_{100}\ P_{75}\ K_{50}$	$T_9= N_{100}\ P_{100}\ K_{50}$
$T_{10}= N_{100}\ P_{25}\ K_0$	$T_{11}= N_{100}\ P_{25}\ K_{25}$	$T_{12}= N_{100}\ P_{25}\ K_{75}$
$T_{13}= N_{100}\ P_{25}\ K_{100}$	T_{14}=Cow dung 10t ha^{-1}	$T_{15}= N_{50}\ P_{12.5}\ K_{25}$ + Cow dung 5t ha^{-1}

Legend

$T_1= N_0\ P_{25}\ K_{50}$	$T_2= N_{50}\ P_{25}\ K_{50}$	$T_3= N_{100}\ P_{25}\ K_{50}$
$T_4= N_{150}\ P_{25}\ K_{50}$	$T_5= N_{200}\ P_{25}\ K_{50}$	$T_6= N_{100}\ P_0\ K_{50}$
$T_7= N_{100}\ P_{50}\ K_{50}$	$T_8= N_{100}\ P_{75}\ K_{50}$	$T_9= N_{100}\ P_{100}\ K_{50}$
$T_{10}= N_{100}\ P_{25}\ K_0$	$T_{11}= N_{100}\ P_{25}\ K_{25}$	$T_{12}= N_{100}\ P_{25}\ K_{75}$
$T_{13}= N_{100}\ P_{25}\ K_{100}$	T_{14}=Cow dung 10t ha^{-1}	$T_{15}= N_{50}\ P_{12.5}\ K_{25}$ + Cow dung 5t ha^{-1}

Fiber content

Significant variation was observed among the treatments in respect of fiber content as shown in Table 2. The highest fiber content (0.39%) was observed in the treatment T_1 (N_0 $P_{25}K_{50}$) followed by T_2 (N_{50} $P_{25}K_{50}$) treatment where as the lowest fiber content (0.21%) was observed in the treatment T_4 (N_{150} $P_{25}K_{50}$) closely followed by T_5, T_3, T_8, T_7 and T_9. Fiber content was decreased by increasing the application of N up to 150 kg ha^{-1} beyond which fiber content again increased. Application of P and K at the rate of 25 and 50 kg ha^{-1} respectively significantly decreases fiber content (0.21%).

Dry matter percent

Dry matter content varied significantly by different fertilizer combinations (Table 2). The maximum dry matter content (9.30%) was found in the treatment T_1 (N_0

$P_{25}K_{50}$) followed by T_2 (N_{50} $P_{25}K_{50}$) and T_{15} ($N_{50}P_{12.5}K_{25}$+ CD 5t/ha). The lowest dry matter (6.45%) was recorded from T_4 (N_{150} $P_{25}K_{50}$) which was closely followed by T_7 and T_8. It was observed that higher dose of N application decreased the dry matter content. On the other hands, application of P and K had no effect on dry matter content.

Days to first flowering

Non significant variation was observed among different fertilizer treatments in respect of days to first flowering (Table 2). However early days to first flowering (44.67 DAS) was observed in the treatment T_3 and late days to first flowering (47.00 DAS) was observed in the treatment T_5.

Days to 50 % flowering

Significant variation was observed among different fertilizer treatments in respect of days to 50% flowering (Table 2). Maximum period of 52.00 days was required in treatment T_4 to get flowering of 50% of the plants. This was closely followed by T_6, T_3 and T_{12} treatments. Earliest flowering of 49.00 days was recorded in T_2 and T_{13} treatments. Higher N levels up to 150 kg ha^{-1} delayed the flowering.

Seed yield

A significant increase in seed yield per plant was observed in response to different fertilizer treatments (Table 2). The highest seed yield /plant (14.12 g) was observed in the treatment T_7 (N_{100} $P_{25}K_{50}$) followed by the treatment T_4 (N_{150} $P_{25}K_{50}$) where as the lowest seed yield/plant (8.75 g) was obtained in the treatment T_1 (N_0 $P_{25}K_{50}$). N dose beyond 100 kg/ha decreased seed yield $plant^{-1}$ (Table 2). Maximum seed yield per plant was obtained from 50 kg P and 50 kg K/ha, respectively. Further increase in levels of P and K did not increase seed yield per plant.

Table 2. Effect of N, P and K on fiber (%), dry matter content (%), flowering, seed yield/ plant, seed yield (t ha^{-1}) and 1000 seed weight of stem amaranth genotype

Treatment	Fibre (%)	Dry matter content (%)	Days to first flowering NS	Days to 50% flowering	Seed yield/plant (g)	Seed yield (t ha^{-1})	1000 seed weight (g)
T_1	0.39a	9.30a	45.00	50.00abc	8.57h	2.83h	0.83abc
T_2	0.36ab	8.85ab	45.00	49.00c	8.93gh	2.95gh	0.86a
T_3	0.27cde	6.75cd	44.67	51.33ab	12.88abc	4.13a-d	0.76abc
T_4	0.21e	6.45d	45.67	52.00a	13.32ab	4.39ab	0.85a
T_5	0.25de	6.90cd	47.00	50.00abc	11.87b-e	4.25abc	0.84ab
T_6	0.33a-d	7.65bcd	45.00	52.00a	9.49fgh	3.13fgh	0.86a
T_7	0.28b-e	6.56cd	45.33	50.33abc	14.12a	4.66a	0.80abc
T_8	0.27cde	6.60cd	44.67	49.33bc	12.53a-d	3.92b-e	0.73c
T_9	0.29b-e	6.68cd	45.67	49.33bc	11.66b-f	3.85b-f	0.78abc
T_{10}	0.31a-d	7.35bcd	46.00	51.00abc	10.47d-h	3.34e-h	0.86a
T_{11}	0.31a-d	7.15cd	45.00	51.00abc	10.95c-g	3.61c-g	0.83abc
T_{12}	0.31a-d	7.45bcd	45.67	51.33ab	10.12e-h	3.45d-h	0.74bc
T_{13}	0.33a-d	7.60bcd	45.00	49.00c	9.79e-h	3.23e-h	0.73c
T_{14}	0.35abc	8.05a-d	45.00	51.00abc	9.11gh	3.01gh	0.82abc
T_{15}	0.34abc	8.10abc	44.67	49.33bc	9.17gh	3.03gh	0.74bc
CV (%)	13.02	10.93	1.89	2.18	11.13	10.79	6.86

Means followed by same letter(s) in a column did not differ significantly from each other by DMRT at 5% level. NS indicates non-significant.

Significant variation was observed among the treatments in respect of seed yield as shown in Table 2. Different levels of N, P and K significantly affected seed yield. The highest seed yield (4.66 t ha^{-1}) was observed in the treatment T_7 ($N_{100} P_{25}K_{50}$) followed by the treatment T_4 ($N_{150} P_{25}K_{50}$) where as the lowest (2.83 t ha^{-1}) seed yield was obtained in the treatment T_1 (N_0 $P_{25}K_{50}$). N dose beyond 100 kg ha^{-1} decreased seed yield per hectare. The maximum seed yield per hectare was obtained from 50 kg P and 50 kg K/ha, respectively. Further increase in levels of P and K did not increase seed yield per hectare. The seed yield per hectare in different treatments varied possibly due to applied treatment effect.

1000 seed weight

Significant variation was observed among different treatments in respect of 1000 seed weight (Table 2). The highest 1000 seed weight (0.86 g) was observed in the treatment T_2 ($N_{50} P_{25}K_{50}$) and T_9 ($N_{100}P_{100}K_{50}$) which was closely followed by T_6 ($N_{100} P_{25}K_{50}$), T_{10} ($N_{100} P_{25}K_0$) and T_4 ($N_{150} P_{25}K_{50}$) where as lowest 1000 seed weight (0.73 g) was observed in T_8 (N_{100} $P_{75}K_{100}$) and T_{13} ($N_{100}P_{25}K_{50}$) treatments. No significant difference was observed among 50, 100 and 150 kg N/ha application in respect of 1000 seed weight. On the other hand no significant difference was found among 0, 25, kg P ha^{-1} and 0, 50 kg K ha^{-1} application respectively in respect of 1000 seed weight.

$T_1= N_0 P_{25} K_{50}$	$T_2= N_{50} P_{25} K_{50}$	$T_3= N_{100} P_{25} K_{50}$
$T_4= N_{150} P_{25} K_{50}$	$T_5= N_{200} P_{25} K_{50}$	$T_6= N_{100} P_0 K_{50}$
$T_7= N_{100} P_{50} K_{50}$	$T_8= N_{100} P_{75} K_{50}$	$T_9= N_{100} P_{100} K_{50}$
$T_{10}= N_{100} P_{25} K_0$	$T_{11}= N_{100} P_{25} K_{25}$	$T_{12}= N_{100} P_{25} K_{75}$
$T_{13}= N_{100} P_{25} K_{100}$	T_{14}=Cow dung 10t ha^{-1}	$T_{15}= N_{50} P_{12.5} K_{25}$ +Cow dung 5t ha^{-1}

Response equations

A one factor quadratic response function was fitted to stem and seed yield of amaranth. Data indicated that for stem production optimum levels of N 165.5 kg, P 64.40 kg and K 52.04 kg ha^{-1} (Fig. 2, 4 & 6) and for seed production optimum levels of N 168 kg, P 55 kg, K 58.5 kg ha^{-1} were required (Fig. 3, 5 & 7).

Optimum nitrogen for maximum stem and seed yield

From Fig. 2, it was seen that stem yield increased with increase of nitrogen dose and the equation showed that the maximum fertilizer for maximum yield was 165.5 kg N/ha. In case of seed yield it was 168 kg N ha^{-1} for seed yield (Fig. 3).These doses were much higher than the optimum dose used in this experiment (100 kg N ha^{-1}). Probably this was due to lack of initial nitrogen status of the soil, soil characteristics and losses of much more nitrogen by different ways such as volatilization, leaching, surface run off etc. From R^2 value (0.9343 and 0.8675 for stem and seed yield ha^{-1}, respectively), it was observed that these doses were highly correlated with yield.

Optimum phosphorus for maximum stem and seed yield

From Fig. 4 & 5 it was found that stem yield and seed yield per hectare of amaranth increased with the increase of phosphorus dose per hectare to a certain level, onward decreased and the equation showed that the maximum fertilizer for maximum stem yield was 64.4 kg P ha^{-1} and in case of seed yield it was 55 kg P ha^{-1}. These doses were much higher than the optimum dose used in this experiment (25 kg P ha^{-1}). From R^2 value (0.8117 and 0.8054 for stem and seed yield per hectare respectively) it was observed that these doses were highly correlated with yield.

Optimum potassium for maximum stem and seed yield

From Fig. 6 & 7 it was found that stem yield and seed yield per hectare of amaranth increased with the increase of potassium dose per hectare to a certain level, onward decreased and the equation showed that the maximum fertilizer for maximum stem yield was 52.04 kg K ha^{-1} and in case of seed yield it was 58.5 kg K ha^{-1}. These doses were higher than the optimum dose used in this experiment (50 kg K ha^{-1}). From R^2 value (0.8089 and 0.7128 for stem and seed yield per hectare respectively) it was observed that these doses were highly correlated with yield.

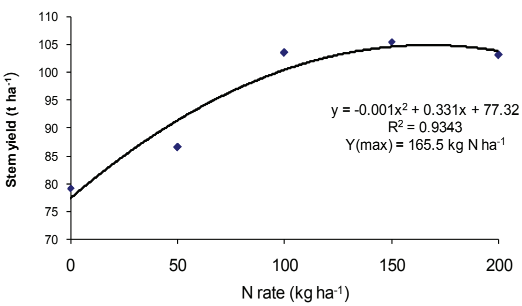

Fig. 2. Effect of N on stem yield of amaranth

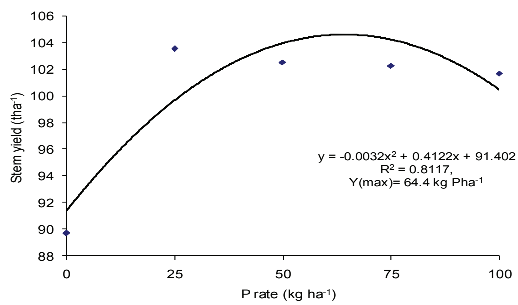

Fig. 4. Effect of P on stem yield of amaranth

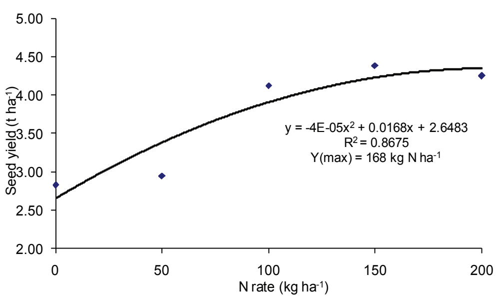

Fig. 3. Effect of N on seed yield of amaranth

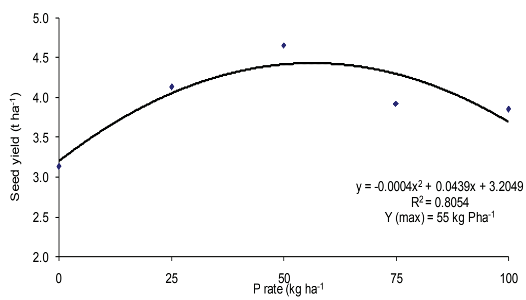

Fig. 5. Effect of P on seed yield of amaranth

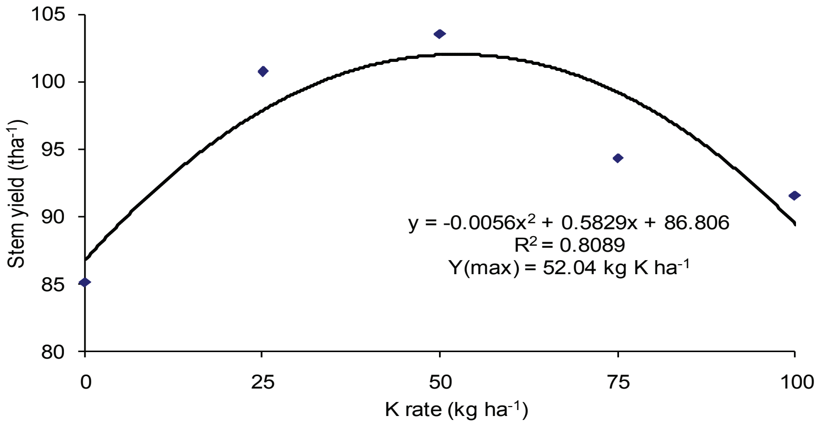

Fig. 6. Effect of K on stem yield of amaranth

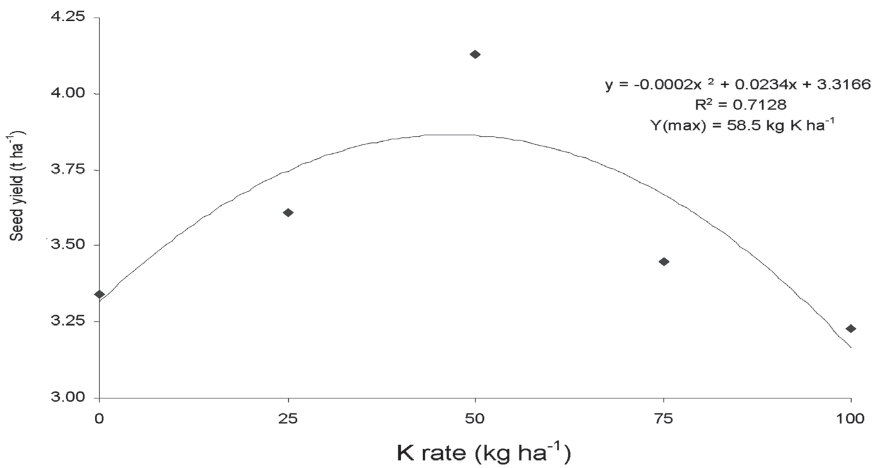

Fig. 7. Effect of K on seed yield of amaranth

Relationship between stem diameter and stem yield (t ha^{-1}) of stem amaranth

A positive linear relationship was observed between stem diameter and stem yield (Fig. 8). It was evident from the figure that the equation y= 4.1118x+3.621 gave a good fit to the data and the value of co-efficient of determination (R^2= 0.7184) showed that the fitted regression line had a significant regression co-efficient. So it indicated that the stem yield increased with the increase of the stem diameter of amaranth.

Relationship between stem weight and stem yield (t ha^{-1}) of stem amaranth

A positive linear relationship was observed between stem weight per plant

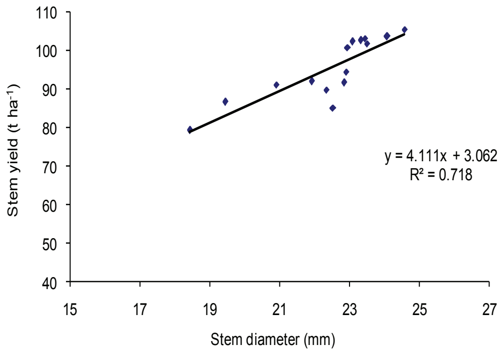

Fig. 8. Relationship between stem diameter and stem yield (t ha^{-1}) of stem amaranth

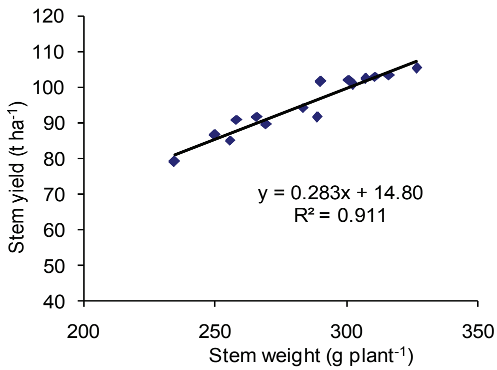

Fig. 9. Relationship between stem weight and stem yield (t/ ha^{-1}) of stem amaranth

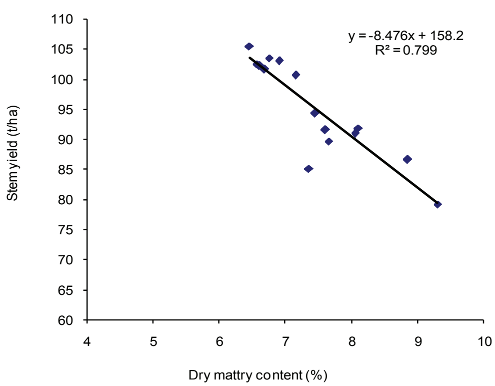

Fig. 10. Relationship between dry matter content and stem yield (t ha-1) of stem amaranth

and stem yield (Fig. 9). It was evident from the Figure 9 that the equation y= 0.2832x+14.807 gave a good fit to the data and the value of co-efficient of determination (R^2= 0.911) showed that the fitted regression line had a significant regression co-efficient. So it indicated that the stem yield increased with the increase of stem weight per plant.

Relationship between dry matter content and stem yield (t ha^{-1}) of stem amaranth

A negative linear relationship was observed between dry matters content and stem yield (Fig. 10). It was evident from Fig. 10 that the equation Y= -8.4767x+158.4 gave a good fit to the data and value of coefficient of determination (R^2=0.7996) showed that the fitted regression line had a significant regression coefficient. So it indicated that the stem yield increased with the decrease of dry matter content.

Conclusion

From the study it may be concluded that N, P and K had a great response on the growth, stem yield and seed yield of amaranth. A combination of macronutrient N_{150} P_{25} K_{50} kg ha^{-1} and $N_{100}P_{50}K_{50}$ kg ha^{-1} were found better for stem and seed production respectively.

References

Ahammed, A.U., M. M. Rahman and M.M. Hossain. 2013. Characterization and evaluation of stem amaranth genotypes in summer season. *Ann. Bangladesh Agric.* 17(1 & 2): 135-149.

BBS. 2011. Year Book of Agricultural Statistics of Bangladesh. Bangladesh Bureau of statistics, Ministry of Planning, Govt. of the Peoples Republic of Bangladesh, Dhaka-1000. p.137.

Bhaskar, J., G.M. Bhasad and S.N. Patil. 1996. Effect of plant population, nitrogen and phosphorus on grain amaranth(Amaranthus sp.) *Indian J. Agron.* 41(1):181-182.

Brammer, H. 1971. Soil resources, Soil Survey Project, Bangladesh, AGL. SF/PAK. 6.Technical Report 3.pp.77-82

Chakhartrakan, S. 2003. Influences of N Fertilizers on the vegetable Amaranth production. Thammasat *Int. J. Sci.* Tech., 8 (2): 1-5.

Gomez, K.A. and A.A. Gomez, 1984. Statistical procedures for Agricultural Research. John Wiley and Sons Publication, New York. pp. 91-97.

Heever, E.V.D., S.L. Venter, O. Ougile, Janse Van Rensburg, M. Mahlangu and I. K. Neluheri. 2006. Effect of Nitrogen on yield and quality of vegetable amaranth. First International Conference on Indigenous vegetables and legumes. ICRISAT Campus, Patan Cheru, Hyderabad, India.p.42.

Joshi, B.D., and R.S. Rana. 1991. Grain Amaranth:The Future Food Crop. Science Mono No. 3. pp.114-115. NGPGR,Shimla.

Magomedov, T.M., A.A. Shumilova and A.A. Fedoseenko. 1997. Dependence of the efficiency of nitrate nitrogen utilization on the photosynthetic activity in C_3 and C_4 plants. Doklady-Biochemistry, 355(1-6):89-90.

Muthukrishnan, C.R. and I. Irulappan, 1986. Amaranthus. In: C.R. Muthukrishnan and I. Irulappan. Amaranthus.p. 670. T.K. Bose and M.G. Som (eds.) 1986. Vegetable crops in India. Naya Prokash, Calcutta six.pp. 670-679.

Rashid, M.M.1999. “Shabjee Biggan” (in Bengali). 2nd Edn. Rashid publishing house, Dhaka-1206. pp.488-491.

Saheed, S.M. 1984. Soils of Bangladesh: general soil types. Soil Resources Development Institute (SRDI), Dhaka, Bangladesh. p.3.

Shanmugavelu, K.G. 1989. Amaranths. In: Production Technology of vegetable crops. Oxford and IBH publishing Co. Pvt. Ltd. New Delhi. pp. 680-699.

Tanaka, A., J. Yamaguchi, S. Mitra and H. Tamaru, 1984. Comparison of fertilizer nitrogen efficiency among field crops. *Soil Sci. Plant Nutri.*, 30 (2): 199-208.