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Evaluating the Impact of Gliricidia *sepium*-Based Alley Cropping Practices on Growth and Yield of Stem Amaranth

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ABSTRACT

Field experiments were performed to study the feasibility of growing stem amaranth in alley cropping system under different alley widths and nitrogen (N) doses. The experiments were set up following split-plot design with three replications. Three alley widths of *Gliricidia sepium* viz. 3.0 m, 4.5 m, and 6.0 m ($W_{3.0}$, $W_{4.5}$, and $W_{6.0}$) comprised the main plot treatment, and five nitrogen (N) doses viz. N_0, N_{25}, N_{50}, N_{75}, and N_{100} (0%, 25%, 50%, 75%, and 100% of recommended N doses, including pruned biomass from *G. sepium*) were distributed as sub-plot treatments. Control plots (without tree) received allied N doses but no pruned material was added. The findings showed that, yield and most of the yield attributes of stem amaranth were found higher in alley cropped plots compared to the control. It was found that, the 3.0, 4.5, and 6.0 m alley widths provided 32, 52 and 68% higher yields of stem amaranth compared to the control (without trees). *Gliricidia sepium*-established alley cropping augmented the crop yields, where the highest stem amaranth yield (55.57 t ha^{-1}) was recorded in 6.0 m alley width with 100% N dose which was statistically similar to 75% and 50% N doses in the wider alley width (6.0 m). The above findings suggest that *Gliricidia sepium*-based alley cropping is a potential approach for increasing crop productivity and reducing synthetic N fertilizer use.

INTRODUCTION

Bangladesh is one of the most densely populated countries in the world with an enormous population of about 169.83 million (BBS, 2022a), and most of them entirely rely on agriculture but the country covers only a cultivable land of 8.09 million hectares (BBS, 2022b) which is inadequate to meet the food demand. Besides, the population is increasing at the rates of 1.22%, and it is anticipated that the population will be augmented to 192.6 million by the year 2050 (UN, 2019; BBS, 2022c). Moreover, the geographical position of Bangladesh, having the Himalayas in the north and the rising tides of the Bay of Bengal to the south, makes it a highly vulnerable country to climate change-induced disasters (Rahman *et al.*, 2018; Naser *et al.*, 2019). Currently, agriculture is facing the problems of soil health degradation, environmental pollution, and most importantly the changing climate (Ferdush *et al.*, 2019). Generally, an ideal soil should contain 2.5% organic matter but unfortunately, most of the soils in Bangladesh contain less than 1.5%, even less than the critical level of 1% (Ahmmed *et al.*, 2018). As a consequence, the capacity of our land is gradually shrinking and exerting tremendous pressure on the limited natural resources of the country to produce food. Furthermore, agricultural lands are shrinking at the rate of 69,000 ha year^{-1} due to a collective approach of urbanization, settlement, and industrialization (Das *et al.*, 2022a; Pingki *et al.*, 2023). In spite of tremendous difficulties, it's now a pressing need to choose alternate farming practices for enhancing crop productivity, reducing environmental pollution, improving soil health, and maintaining the sustainability of production.

To address the issue of crop productivity and soil environment, different farming practices viz. tree-crop intercropping, organic farming, ecological farming etc. have emerged, out of which agroforestry could be a suitable candidate to ensure sustainable production and overcome future challenges (Das *et al.*, 2022b; Rita *et al.*, 2024). Agroforestry is the integration of trees with crops/vegetables on the same piece of land, where the annual crops are successfully grown in association with woody perennials, maintaining a well-balanced spatial and temporal arrangement. It provides a sound ecological basis to enhance systems' overall productivity, soil fertility, and socioeconomic conditions of farming communities (Miah *et al.*, 2022; Rahman *et al.*, 2024). Among the different agroforestry systems, alley cropping is an auspicious approach which integrates leguminous tree species within cropping systems (Tuan *et al.*, 2014). In this system, the tree legumes are regularly cut down to minimize the competitions between trees and crops, and are added to the soil to improve the physico-chemical properties; which ultimately improve the crop productivity. Hombegowda *et al.* (2022) reported that, alley cropping minimizes soil erosion, regenerate degraded land, and

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improve soil health for successful crop cultivation. A lots of legume species viz. *Gliricidia sepium*, *Cassia siamea, Leucaena leucocephala, Cajanus cajan, Indigofera tysmanii, Senna siamea*, etc. are used in alley cropping practices, and *Gliricidia sepium* is the most suitable one (Rahman *et al.*, 2009; Ahmed *et al.*, 2010; Sirohi *et al.*, 2022; Koyejo *et al.*, 2023). *G. sepium* is a fast-growing multipurpose tree species that provides ecosystem services such as soil health improvement, recycling of nutrients, soil preservation, nitrogen fixation, carbon sequestration, and it grows well in various types of soil including acidic, alkaline, sandy, and heavy soils (Medinski & Freese, 2012; Braga *et al.*, 2022). It's a good source of minerals and application of biomass known to be effective for enhancing soil health (Wartenberg *et al.*, 2017).

Several studies reported that, soil properties viz. organic carbon, soil minerals, and microbial populations were found to be improved due to application of *G. sepium* tree legume in the cropping systems (Dinesh *et al.*, 2010; Bai *et al.*, 2017; Coser *et al.*, 2018; Partey *et al.*, 2019; do Rego Barros *et al.*, 2021). Fascinatingly, the species successfully improved the growth and yield of maize, tomato, cotton, soybean, and groundnut compared to the sole cropping (Bandara *et al.*, 2017; Mng'omba *et al.*, 2017; Nyirenda, 2019). However, application of *G. sepium* in alley cropping practices is still limited in Bangladesh and the wider applicability needs rigorous scientific investigation. In Bangladesh, a large number of vegetables are grown of which 70% are cultivated in winter season (Akter *et al.*, 2016). During summer, a limited number of vegetables are grown out of which stem amaranth is the most common. Stem amaranth is a good source of vitamins, essential amino acids like methionine and lysine, minerals, and dietary fibre (Sarker *et al.*, 2014; Sarker *et al.*, 2018) which could be a suitable option to grow under *G. sepium*-based alley practices. Considering the above-mentioned facts, the present study was conducted to evaluate the growth and yield of stem amaranth grown under different alley widths of *G. sepium* at varying nitrogen levels.

MATERIALS AND METHODS

Description of Study Area

The experiment was setup and accomplished at the farm of the alley cropping system in Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh. The location of the study area is presented in Figure 1. After completion of the experiment during the summer season of 2017 (April-June), the study was repeated for another summer season of 2018. The soil where the experiment was done belonged to the Madhupur Tract of AEZ-28 and was originally shallow red-brown terrace soil under Salna Series (Brammer, 1996). The experimental area has a subtropical climate and has been characterized by three distinct seasons:

i. May to October (monsoon or rainy season),
ii. November to February (winter or dry season), and
iii. March to April (pre monsoon or hot season).

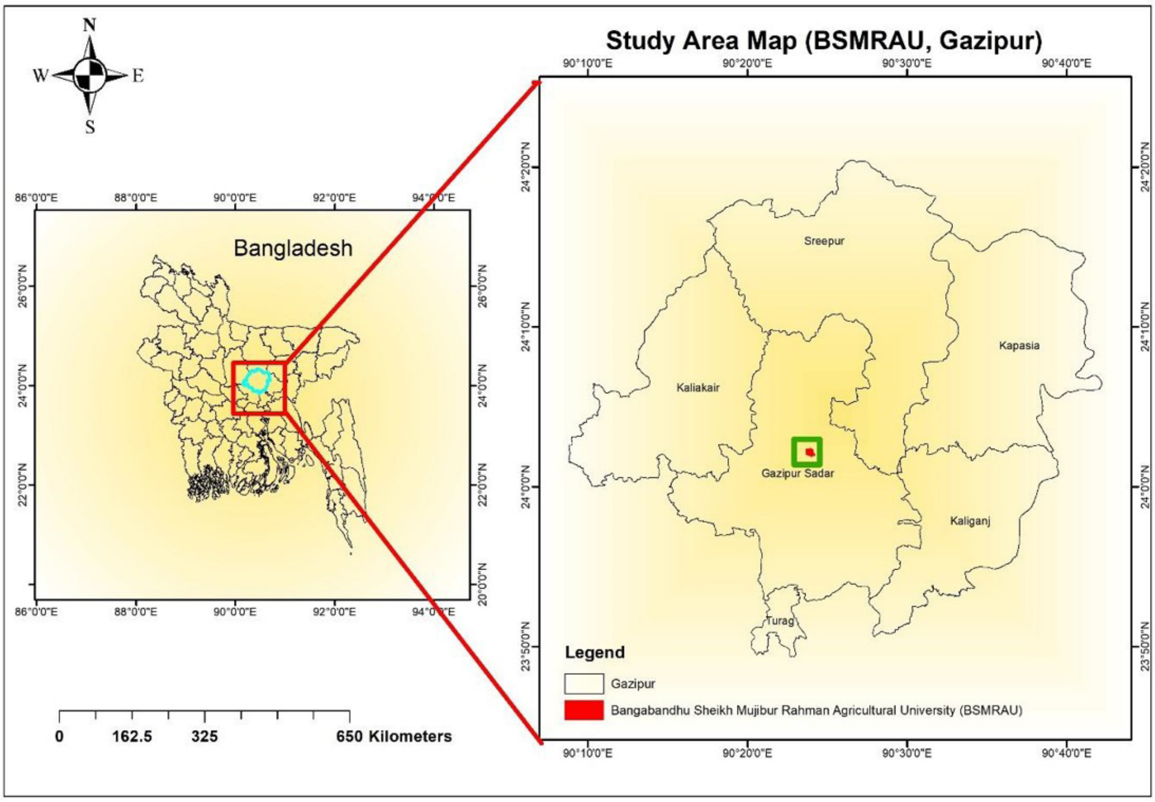

Figure 1: A map displaying the study area

Hedgerow Establishment, Pruning and Addition of *G. sepium* Biomass into Soil

Seedlings of *Gliricidia sepium* were transplanted in the experimental field during September 2005, maintaining a tree to tree distance of 50 cm in each line. For the proper establishment of hedgerow, each seedling was fertilized with 2 kg cowdung, 20 g TSP and 10 g MoP fertilizers and adequate management practices were also performed. Hence, a twelve years aged *G. sepium* alley field was used in this present study. To incorporate the fresh green biomass of *Gliricidia sepium* into the soil in different alleys, pruning was done on March 02, 2017 for the first season trial and March 04, 2018 for the second season experimentation. The harvested pruned materials were spread to the soil in between the alleys of different widths accordingly and mixed with the soil thoroughly with the help of disc plow and rotavator. The amount of pruned materials obtained from different alley widths during both the experiments have been presented in Table 1. Subsequently, irrigation was provided for facilitating the biomass to be well decomposed so that the nutrients can be easily released and added to the soil; thus improving the fertility status of the plots in consequences.

Table 1: Fresh biomass of *Gliricidia sepium* obtained from different alley widths during the years 2017 and 2018

Alley width	Pruned materials of *Gliricidia sepium* (t ha^{-1})	
	2017	2018
3.0 m	10.55	11.15
4.5 m	7.28	7.36
6.0 m	5.59	5.68

Experimental Design and Treatments

Split-plot design with three replicates was followed to execute the field experiment on stem amaranth in the *Gliricidia sepium* tree-based alley cropping system. Three different alley widths viz. $W_{3.0}$, $W_{4.5}$, and $W_{6.0}$ (3.0 m, 4.5 m, and 6.0 m) were considered as the main plot treatments, and five different N doses viz. N_0, N_{25}, N_{50}, N_{75}, and N_{100} (0%, 25%, 50%, 75%, and 100% of recommended N dose) along with pruned materials from *G. sepium* were arranged in sub-plots within every main plot. At first, each alley and control area were divided into 15 unit plots considering the five different levels of nitrogen dose with three replications. Control plots (without tree) received allied N doses but no pruned material was added. Thus, the present study constituted a total of 60 unit plots. The length of each unit plot was 5.0 m; hence, total area of each unit plot was 3.0 × 5.0 m, 4.5 × 5.0 m, and 6.0 × 5.0 m for 3.0, 4.5, and 6.0 m alleys, respectively. The size of individual control plot was 3.0 × 5.0 m. A popular variety of stem amaranth BARI Danta -1 (Laboni) was used as a test crop in this experiment.

Land Preparation, Seed Sowing and Intercultural Operations

The experimental plots between two lines of tree (i.e. alley) were prepared very well by plowing with a small tractor followed by harrowing and laddering. All the weeds and stubbles were removed and the land was prepared properly for sowing seeds. After final land preparation, the seeds were drilled in by hand on 12 April 2017 and 10 April 2018, respectively for both of the experiment. The seeds were sown maintaining a 30 cm line to line distance and continuously within the rows. As the seeds were very small, it was covered by a thin layer of loose fertile sandy loam soil. Fertilizers were applied in the experimental plots at the rates of urea 250 Kg ha^{-1}, triple superphosphate (TSP) 150 Kg ha^{-1}, muriate of potash (MoP) 150 Kg ha^{-1} and gypsum 75 Kg ha^{-1} (Azad *et al.*, 2017). The entire quantity of TSP, MoP and gypsum were applied at the time of final land preparation. Urea was applied to the crop as per the treatments of the experiment in three equal installments at 15, 35, and 50 days after sowing (DAS) as top dressing in both the seasons of 2017 and 2018. Thinning and weeding were done three times in both the experiment at 15, 22, and 29 DAS and finally the spacing of 30 cm × 10 cm was maintained for stem amaranth. First irrigation was provided 5 days after sowing, and another five irrigations were given at 15, 25, 35, 50, and 60 DAS, respectively using a suitable hose pipe. Pest and disease control measures were taken as per requirements on a regular basis.

Crop Harvesting and Data Collection

To assess the growth and yield of stem amaranth, harvesting was done at 70 DAS and data were recorded on plant height, stem diameter, number of leaves plant^{-1}, fresh weight plant^{-1}, yield (t ha^{-1}), and dry matter percentage. To minimize the error, ten plants were randomly selected and harvested from each unit plot according to treatments to consider as one replication.

Statistical Analysis

The experimental data were statistically analyzed using the two-way "Analysis of Variance" (ANOVA) technique with the help of computer package "Statistix 10.0" and MS Excel to examine the significant variation of the results due to different treatments. Further, the mean differences among the treatment combinations were evaluated by Tukey's HSD test at a 5% level of probability for the interpretation of results. Pooled analysis of two year's data were done using the R-Software package.

RESULTS AND DISCUSSION

Plant Height

Plant height of stem amaranth varied among different alley widths ranged from 75.2 cm to 79.4 cm (Figure 2A). The highest plant height (79.4 cm) was measured in 3.0 m alley width, while the lowest (75.2 cm) was in control. The closer the alley width, the higher the plant height was exhibited in the treatments of different alley widths, which might be attributed to the apical dominance under low light conditions (Cline, 1991). Different nitrogen (N) levels exhibited wide variation regarding plant height of stem amaranth at harvest and augmented with the enhancement of N levels (Figure 2B). The maximum plant height (82.2 cm) was recorded in N_{100} treatment and the minimum (70.3 cm) was in N_0. Interestingly, when N levels were increased, the plants height were also increased and the findings are in agreement with Mondal *et al.* (2013).

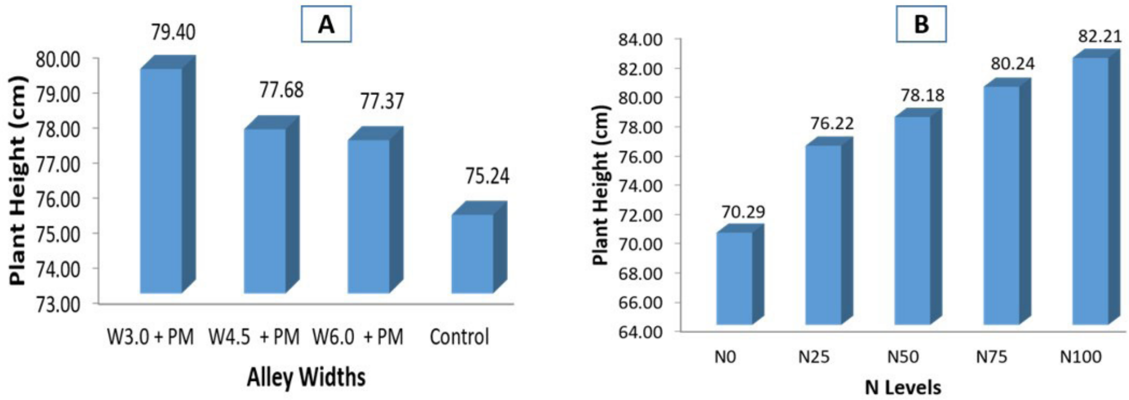

Figure 2: Effect of alley widths (A) and N levels (B) on plant height of stem amaranth at harvest (Pooled over two years)

The combined effect of different alley widths and N levels showed marked variation in plant height at harvest (Table 2). The highest plant height (84 cm) was found in 3.0 m alley width with 100% N level which was statistically at par with all of the treatment combinations, except 0% N level in control. In our study, the main effects of alley widths indicated that the lower the alley width had the shading effect on plants which resulted the apical dominance and reflected in higher plant height. But when N levels were increased, the plant's height was found to increase, probably suppressing the apical dominance, and thus, the main effect of different N levels resulted in higher plants' height. Similar findings were also reported in brinjal and rice under alley cropping practices (Ahmed *et al.*, 2010; Mondal *et al.*, 2013).

Stem Diameter

Stem diameter was varied among the alley widths, where the highest diameter (22.1 mm) was recorded in control and the lowest (21.2 mm) was in 4.5 m alley (Figure 3A). The main effect of N levels showed marked differences on the diameter of stem, and it was increased with the increase in N levels (Figure 3B). In response to different N levels, the highest stem diameter (25.1 mm) was found in N_{100} treatment, while the lowest diameter (17.2 mm) was recorded in N_0.

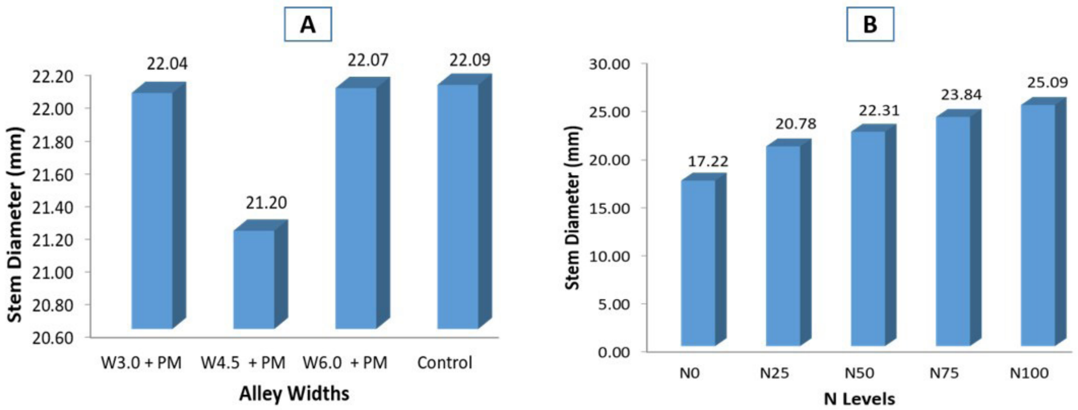

Figure 3: Effect of alley widths (A) and N levels (B) on diameter of stem amaranth at harvest (Pooled over two years)

The interaction effect of alley widths and N levels resulted in no significant variations ($p > 0.05$) in stem diameter. The highest stem diameter (26.1 mm) was measured in $W_{6.0} \times N_{100}$ treatment combination which was statistically comparable with $W_{3.0} \times N_{100}$, Control$\times N_{100}$ $W_{3.0} \times N_{75}$, $W_{6.0} \times N_{75}$, Control$\times N_{75}$, and $W_{4.5} \times N_{100}$ treatment combinations (Table 2). The lowest diameter of stem (17.5 mm) was found in Control$\times N_0$ treatment combination. The findings revealed that, stem diameter was basically influenced by N levels which increased gradually with the increase in N fertilizer irrespective of alley widths whether green biomass was incorporated or not. It implied that the nitrogenous fertilizer along with the incorporation of green biomass had the major contribution in increasing the diameter of stem. The findings of the present study also corroborated and reported by several researchers (Ahmed *et al.*, 2010; Islam *et al.*, 2014; Ahammed *et al.*, 2015).

Table 2: Combined effect of alley widths and N levels on plant height, stem diameter and number of leaves plant^{-1} of stem amaranth (pooled over two years)

Treatment combinations	Plant height (cm)	Stem diameter (mm)	Number of leaves plant^{-1}
$W_{3.0}$×N_0	72.10ab	17.2cd	15.50ab
$W_{3.0}$×N_{25}	78.02ab	21a-d	16.50ab
W3.0×N_{50}	79.96ab	22.2a-d	17.17ab
$W_{3.0}$×N_{75}	82.80ab	24.5ab	17.50ab
$W_{3.0}$×N_{100}	84.15a	25.3ab	18.83a
$W_{4.5}$×N_0	72.43ab	16.9d	15.83ab
$W_{4.5}$×N_{25}	75.45ab	20.5a-d	16.50ab
$W_{4.5}$×N_{50}	77.72ab	22a-d	16.83ab
$W_{4.5}$×N_{75}	80.51ab	22.7abc	18.17a
$W_{4.5}$×N_{100}	82.30ab	23.9ab	18.17a
$W_{6.0}$×N_0	69.54ab	17.4cd	15.17ab
$W_{6.0}$×N_{25}	76.16ab	20.4bcd	15.83ab
$W_{6.0}$×N_{50}	78.30ab	22.4a-d	15.50ab
$W_{6.0}$×N_{75}	79.97ab	24.2ab	16.50ab
$W_{6.0}$×N_{100}	82.89ab	26.1a	16.83ab
Control×N_0	67.07b	17.5cd	13.50b
Control×N_{25}	75.23ab	21.2a-d	14.50ab
Control×N_{50}	76.74ab	22.6a-d	14.50ab
Control×N_{75}	77.68ab	24.1ab	15.17ab
Control×N_{100}	79.50ab	25.1ab	15.83ab
CV (%)	6.96	15.9	6.50

In a column, small alphabetical letter(s) showed significance level among the treatment means at 5% level of probability by Tukey's HSD test

Number of Leaves Plant^{-1}

Number of leaves plant^{-1} is one of the most important parameters responsible for plant photosynthesis. Different alley widths had shown significant variation ($p< 0.05$) as regards to the production of leaves of stem amaranth per plant. It was found that the number of leaves produced per plant due to different alley widths was comparatively higher than control (14.70). The highest number of leaves plant^{-1} (17) was recorded in the treatment $W_{3.0}$ + PM, which was exactly similar to that produced by plants grown in $W_{4.5}$ + PM treatment (Figure 4A). The lowest number of leaves plant^{-1} (15) was found in treeless plot (Control). On the other hand, remarkable variation was reflected on the number of leaves plant^{-1} due to the varied level of N (Figure 4B). It varied from 15-17.42; being the maximum number in N_{100} and the minimum in N_0 treatment. The number of leaves plant^{-1} was gradually increased along with the increasing doses of N fertilizer and each treatment produced the leaves which were distinctly different from others.

The combined effect of alley widths and N levels on the number of leaves plant^{-1} was found significant ($p< 0.05$). The maximum number of leaves plant^{-1} (19) was found in $W_{3.0}$×N_{100} treatment combination, which

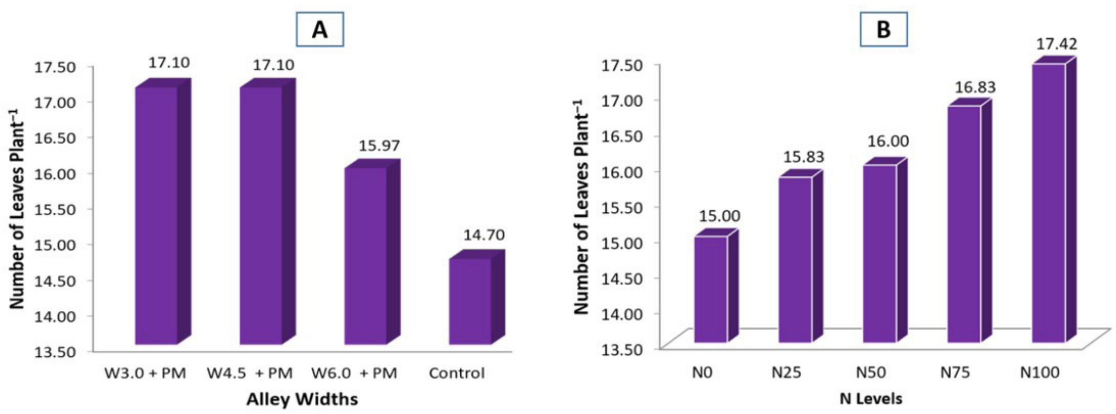

Figure 4: Effect of alley widths (A) and N levels (B) on number of leaves plant^{-1} of stem amaranth at harvest (Pooled over two years)

was statistically similar with $W_{4.5}\times N_{100}$ and $W_{4.5}\times N_{75}$ treatment combinations (Table 2). The significantly lowest number of leaves plant^{-1} (13.5) was obtained from Control×N_0 treatment combination. As like other parameters described earlier, it would be seen that the number of leaves plant^{-1} increased linearly with the increasing amount of N fertilizer irrespective of different alley widths. Nitrogenous fertilizer application coupled with plant nutrients addition from pruned biomass of *G. sepium* might have enhanced the number of leaves plant^{-1} and this finding has been supported by Ahmed *et al.* (2010) and Islam *et al.* (2014).

Fresh Weight Plant^{-1}

There had a significant difference ($p< 0.05$) pertaining to the fresh weight plant^{-1} of stem amaranth due to the main effect of alley widths. In response to different alley widths, the highest fresh weight (197.7 g) was measured in 3.0 m alley width, while the lowest fresh weight plant^{-1} (150 g) was obtained from treeless plot (Figure 5A). Similarly, distinct variation was observed on fresh weight plant^{-1} due to variable nitrogen doses; being the highest (198.3 g) in N_{100} treatment and the lowest (148.3g) in N_0 treatment (Figure 5B).

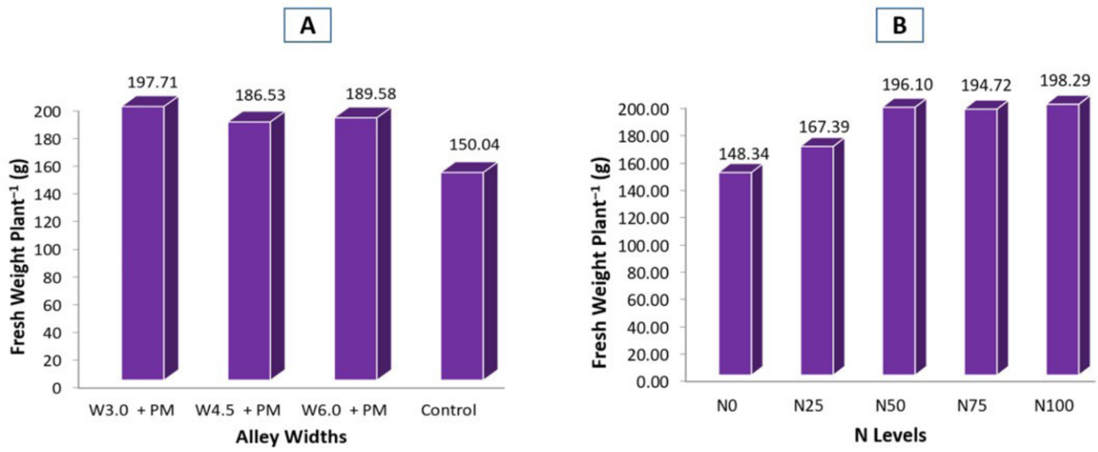

Figure 5: Effect of alley widths (A) and N levels (B) on fresh weight plant^{-1} of stem amaranth at harvest (Pooled over two years)

The fresh weight was found to increase with the rise in the quantity of N fertilizer applied except N_{75} treatment (194.7 g), while N_{50} treatment produced the fresh weight of 196.1 g. More nitrogen application encourages the good vegetative growth which had been reflected through higher fresh weight plant^{-1} of stem amaranth in higher N levels. The combined effect of alley widths and N levels showed significant variations ($p< 0.05$) on the fresh weight plant^{-1} of stem amaranth. The maximum fresh weight plant^{-1} (220 g) was measured in $W_{3.0}\times N_{100}$ treatment combination, which was swiftly followed by 100%, 75%, and 50% N combinations under all the studied alley widths (Table 3). In contrast, the minimum fresh weight plant^{-1} (128 g) was recorded in 0% N level under absence of *G. sepium* tree (control). Pruned materials from *G. sepium* legumes might have supplied considerable amount of plant nutrients especially N to the crops, which might have improved the growth of plants and ultimately resulted in high fresh weight plant^{-1} of stem amaranth under alley cropped plots compared to the control. The present findings are in best agreement with other reported findings (Basak *et al.*, 2011; Hasan *et al.*, 2014; Islam *et al.*, 2014; Coe *et al.*, 2019).

Table 3: Combined effect of alley widths and N levels on fresh weight plant^{-1}, yield ha^{-1} and dry matter (%) of stem amaranth (pooled over two years)

Treatment combinations	Fresh weight plant^{-1} (g)	Yield (t ha^{-1})	Dry matter (%)
$W_{3.0}\times N_0$	161.93d-g	32.39e-h	10.53ab
$W_{3.0}\times N_{25}$	182.89a-e	36.58c-g	10.65a
W3.0×N_{50}	212.08ab	42.42b-e	9.96a-f
$W_{3.0}\times N_{75}$	211.65ab	42.33b-e	9.39d-g
$W_{3.0}\times N_{100}$	220.01a	44.00bcd	10.07a-e
$W_{4.5}\times N_0$	146.85efg	35.90d-g	9.14fg
$W_{4.5}\times N_{25}$	175.19bcd	42.82bcd	9.74a-g
$W_{4.5}\times N_{50}$	206.84abc	50.56ab	10.01a-f
$W_{4.5}\times N_{75}$	199.54a-d	48.78ab	9.44c-g
$W_{4.5}\times N_{100}$	204.26abc	49.93ab	10.12a-d

$W_{6.0}\times N_{0}$	156.67efg	41.78b-f	9.19efg
$W_{6.0}\times N_{25}$	173.37c-f	46.23abc	9.71b-g
$W_{6.0}\times N_{50}$	204.47abc	54.53a	9.98a-f
$W_{6.0}\times N_{75}$	205.04abc	54.68a	9.48c-g
$W_{6.0}\times N_{100}$	208.37abc	55.57a	10.32abc
Control$\times N_{0}$	127.93g	25.59h	8.99g
Control$\times N_{25}$	138.13fg	27.63gh	9.42c-g
Control$\times N_{50}$	161.01efg	32.20fgh	9.36d-g
Control$\times N_{75}$	162.64d-g	32.53e-h	9.30d-g
Control$\times N_{100}$	160.51efg	32.10fgh	9.80a-g
CV (%)	6.81	7.87	3.08

In a column, small alphabetical letter(s) showed significance level among the treatment means at 5% level of probability by Tukey's HSD test

Yield of Stem Amaranth

The yield of stem amaranth was significantly assorted ($p< 0.05$) due to the main effect of alley widths. The yield varied from 30.01-50.56 t ha^{-1}, and it was increased along with the increase in alley widths.

The results showed that, 6.0 m alley width provided the highest (50.56 t ha^{-1}) yield of stem amaranth while control treatment exhibited the lowest (30.01 t ha^{-1}) yield (Figure 6A). The widest alley width along with the incorporation of pruned materials triggered to have the maximum stem amaranth yield. Although, the individual plant weight was found to be maximum in 3.0 m alley width, but per hectare yield was maximum in 6.0 m alley which happened due to the large number of stem amaranth association per hectare of land under 6.0 m alley width compared to others. Fascinatingly, stem amaranth yields were higher in all the alley widths compared to the control which proved that, pruned materials from *G. sepium* positively influenced the growth and yield of stem amaranth. Likewise, the main effect of different N levels had shown significant variation ($p< 0.05$) regarding the yield of stem amaranth.

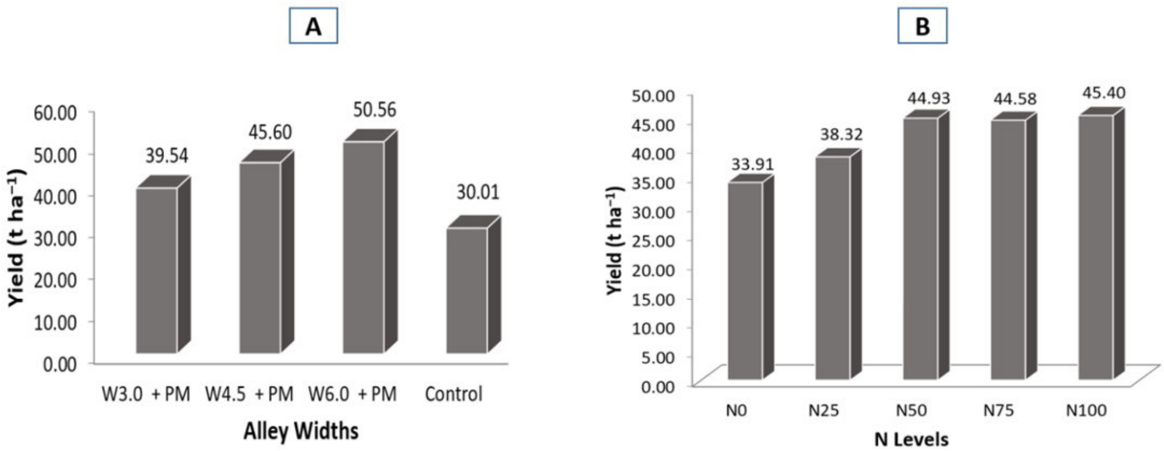

Figure 6: Effect of alley widths (A) and N levels (B) on yield of stem amaranth at harvest (Pooled over two years)

In response to different N levels, N_{100} treatment provided the maximum yield (45.4 t ha^{-1}) while the minimum yield (33.9 t ha^{-1}) was found in N0 treatment (Figure 6B). The findings are in agreement with Ahammed *et al.* (2015) who reported that N fertilizer significantly increase the yield of stem amaranth.

Furthermore, we investigated the combined effect of alley widths and N levels to determine which treatment combinations provide the highest yield with reduced use of synthetic N fertilizer. The results showed that, the yield was significantly ($p<0.05$) varied among different treatment combinations ranged from 25.59-55.57 t ha^{-1}. The highest yield (55.57 t ha^{-1}) was obtained from $W_{6.0}\times N_{100}$ treatment combination, which was statistically identical with $W_{6.0}\times N_{75}$ and $W_{6.0}\times N_{50}$ treatment combinations (Table 3). In contrast, the lowest stem amaranth yield (25.59 t ha^{-1}) was recorded under Control$\times N_{0}$ treatment combination. *G. sepium* tree legume might have supplied sufficient N through decomposition of fresh pruned materials and biological N_2 fixation, which ultimately improved the growth and yield of stem amaranth. Moreover, *G. sepium*-established alley cropping showed that, it is possible to save synthetic N fertilizer up to 50% without significant yield loss, if pruned biomass from *G. sepium* trees are used in a 6.0 wide alley. Our findings concomitated with others particularly when cabbage, brinjal, tomato, rice, maize, cotton, soybean etc. are grown in association with *G. sepium* trees (Rahman *et al*., 2009; Ahmed *et al*., 2010; Mondal *et al*., 2013; de Moura-Silva *et al*., 2016; Mng'omba *et al*., 2017).

Dry Matter Content

The main effect of alley widths on dry matter content of stem amaranth was found insignificant (p> 0.05). Results revealed that, the highest dry matter (10.12%) was recorded in stem amaranth grown under 3.0 m wide alley, while the lowest (9.37%) in control (Figure 7A). The dry matter percentages of the crop were higher in alley cropped plots compared to the control. The addition of green biomass in the interspaces of the alleys might have enriched the soil fertility and thus the crop growth and development was higher and consequently it had been reflected through higher dry matter percentage of amaranth stem.

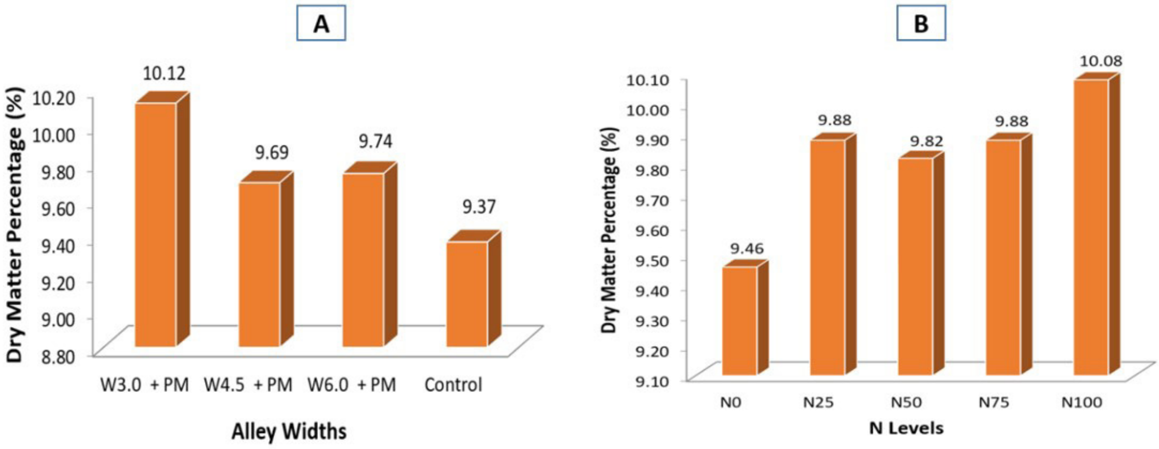

Figure 7: Effect of alley widths (A) and N levels (B) on dry matter (%) of stem amaranth (Pooled over two years)

The dry matter content of stem amaranth was significantly assorted (p< 0.05) due to the main effect of different N levels, where it ranged from 9.46-10.08%. The highest dry matter (10.08%) was found in crops grown in N_{100} treatment, while the lowest dry matter (9.46%) was given by N_0 treatment (Figure 7B). The combined effect of alley widths and different N levels showed significant variation (P< 0.05) regarding dry matter content of stem amaranth ranged from 8.99-10.65%. Results showed that, $W_{3.0} \times N_{25}$ treatment combination given the highest dry matter content (10.65%), while the lowest (8.99%) was recorded in plants grown under Control×N_0 treatment combination (Table 3). Although, the dry matter percentages of stem amaranth were found higher under different treatment combinations with higher N level irrespective of alley width and control except 3.0 m alley width, but it responded irregularly under different treatment combinations which need to be thoroughly assessed.

CONCLUSION

Yield and yield attributes of stem amaranth were positively influenced under *G. sepium*-based alley cropping practices compared to the treeless condition (control). The findings showed that, pruned biomass application from *G. sepium* tree augmented the stem amaranth yields. Therefore, the highest and comparable yields of stem amaranth were observed in 6.0 m alley width with 100%, 75%, and 50% N doses, indicating that it is possible to save inorganic N fertilizer up to 50% without significant yield loss of stem amaranth. The aforesaid reduction in the use of synthetic N fertilizer would be economically advantageous for the subsistence farmers and ecologically sound. Hence, an alley cropping system could be recommended for the farmers; however, the wider dissemination of this green technology needs rigorous scientific investigation, particularly conducting economic investigations on the farmer's field.

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