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Nutrient management and effects of netting on growth and yield of Indian spinach (*Basella alba*)

M. Mishu Akther[1], M. Ashraful Islam [1*], M. Saidee Rahman[1], M. Rezaul Karim [1], Dilip Nandwani[2]

[1]Department of Horticulture, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh; mishu.bau4@gmail.com (M.M.A); ashrafulmi@bau.edu.bd (M.A.I); imran.bau4@gmail.com (M.S.R); mrkarim1996@yahoo.com

[2]Department of Agriculture and Environmental Sciences, College of Agriculture, Tennessee State University, Nashville, TN 37209, USA; dnandwan@tnstate.edu (DN)

Correspondence: ashrafulmi@bau.edu.bd and dnandwan@tnstate.edu

Abstract: Best horticulture management has been practiced to reduce the amount of inorganic fertilizer in connection with net (mosquito net) for higher production of Indian spinach. Excessive use of chemical fertilizers in agriculture promoted negative effect on the environment and human health in Bangladesh. The experiment was conducted at the Horticulture Farm of Bangladesh Agricultural University (BAU), Mymensingh during the period February to May 2016. Two factor experiments were conducted on nettings: control (N_0), Netting (N_1) and different fertilizers: control (F_0), Vermicompost 10 t/ha (F_1), Vermicompost 15 t/ha (F_2), 2/3rdof F_2+ 1/3rdof F_4 (F_3), Inorganic fertilizer (F_4). Combination of mosquito net and combined of organic and inorganic fertilizers (N_1F_3) gave the significantly higher growth and yield of Indian spinach compared to other treatment combination. The maximum vine length (77.71 cm), after 45 days after sowing was found from N_1F_3 which was 72% higher compared to control. The highest yield of Indian spinach was 38.67 t/ha from N_1F_3 which was 80% higher compared to control. The treatment combination of N_1F_3 provided maximum leaf numbers per plant, leaf length.

Key word: Inorganic fertilizer, Vermicompost, Net, Growth, Yield, Indian spinach

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Introduction

The use of inorganic fertilizer and chemical pesticide since green revolution has been increased to enhance crop production in agriculture. Benefits on improved yields in crops received, however, unforeseen environmental impacts, human health hazard and resistance to pests and diseases impacted negatively over the years [1].Organic fertilizers are environmentally friendly and improve soil health, water-holding capacity, high cation exchange capacity and low bulk density; and they a foster diverse population of beneficial soil microorganisms [2]. Now-a-days people are getting attention to use of organic fertilizer and organic pesticide in crop field because it is eco-friendly, safe and has benefits for human health. Consumers believe that organically produced agricultural products are nutritious, taste good and safe as well as has little or no adverse effect on the environment compared to inorganic or conventional farming practice [3].

Netting refers covering the crops using net (mosquito net) to provide shade of the crop. It improved micro-environment of crop field, protect crop from environmental hazards and protection from insect pest damage. Agricultural production is affected due to increase in air temperature and intensity of solar radiation result of the climatic change and urbanization (Reference?). Colour shade can be helpful to improve the microenvironment for plant growth. Several reports are available usedof shade nets to protect agricultural crops from excessive solar radiation and to improve the thermal climate [4].Vermicompost is a type of organic fertilizer which is produced by a non-thermophylic process involving interactions between earthworms and micro-organisms leading to bio-oxidation and stabilization of organic material [5,6]. Applications of vermicompost in combination with chemical fertilizers have been proved effective to enhance growth and yield of different crops like cabbage, tomato and strawberry [7 - 9].Actually mixed fertilizers (combination of organic and inorganic fertilizers) provide nutrient all over growing periods of crops as a result good vegetative growth occur in plant. This combination results in higher yield of crops encourages to reduce the amount of chemical fertilizers application.

Indian spinach is a nutrient rich leafy vegetable grown in the summer season in Bangladesh. It is a fleshy annual, twining much branched herb with alternate ovate leaves. There are two varieties, green and red. The nutritive value of Indian spinach is very high with a good content of minerals, vitamins and substantial amount of fibers [10].

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The conventional agriculture is becoming flop and sustainability of crop production is demanding in this era in Bangladesh. Already, there some findings of higher production of crops through mixed of organic and inorganic fertilizers [7-8]. No research has been conducted in Bangladesh on the Indian spinach production considering the net and fertilizer management combination. This study was conducted to evaluate the effect of nutrient management system through application of organic and inorganic fertilizers with or without mosquito net covering the crop on the growth and yield of Indian spinach.

2. Materials and methods

An experiment on Indian spinach was conducted at the Horticulture Farm (24^0 26' and 24^0 54' N latitude and 90^0 15' and 90^0 30' E longitude) of Bangladesh Agricultural University, Mymensingh during the period February to May 2016 to evaluate the effects of netting (blue color mosquito net) and different fertilizers on the growth and yield. Five levels of fertilizer viz., F_0 (control); F_1 (Vermicompost 10 t/ha); F_2 (Vermicompost 15 t/ha); F_3, combined fertilizer(2/3rdof F_2+ 1/3rd of F_4 treatment), F_4 (Inorganic fertilizer) and two levels of netting viz., N_0 (Control), N_1 (Netting). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Inorganic fertilizer (F_4) were given (100 kg N +22 kg P + 70 kg K + 18 kg Zn /ha) according to FRG [11]. Indian spinach of green color variety seeds was used as the planting material at the rate 1.170 kg/ha.Seeds were soaked overnight in a wrapped cotton cloth.Seeds were sown in the field at afternoon in a depth of 1.5 cm in dibbling method spaced at 40×25 cm. Seedlings (or transplants) were covered with insect net at 4' height . Organic fertilizers (vermicompost), triple superphosphate (TSP), ZnSO4, were applied before planting. Vermicompost was obtained from Horticulture farm of BAU.Vermicompost nutrient composition varies (N: 0.5%–4%, P: 0.5%–3%, K: 0.5%–3%, and S: 0.1%–0.5%, personal communication BARC, Bangladesh).Urea and MoPwere applied at three applications at 1st, 3rd and 5th weeks of seeding respectively.Weeding and irrigation were done manually. Three replications with eight plants per plot/ randomly designed for the experiment and labeled. Data were collected on vine length (cm), leaf number, leaf length (cm), vine diameter (cm), yield per plot (t/ha),fresh and dry weight of leaves and vines were recorded. Fresh leaves and vines kept in an oven for drying at 65 ^{0}C for 3 days. Data were statistically analyzed by analysis of variance (General Linear Model procedure) and Tukey's pair wise comparison test ($p < 0.05$) using Minitab Version 17 (Minitab Inc., State College, PA, USA).

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3. Results and Discussion

Vines with leaves were harvested three times above 10-15 cm from ground level. First harvest was done after 45 days after sowing seeds (DAS). Growth trends data like vine length or plant height, leaves numbers and length, vine diameter were recorded frequently before the first harvest. After harvesting, plant produces more branches and influences yield. Three tharvests were done and collective yield were significantly different among the treatment combinations. Analysis of variance showed that the highest vine length and yield were highly significant in the application of organic and inorganic fertilizer with mosquito net treatment (N_1F_3) (Figure 1 and 2).

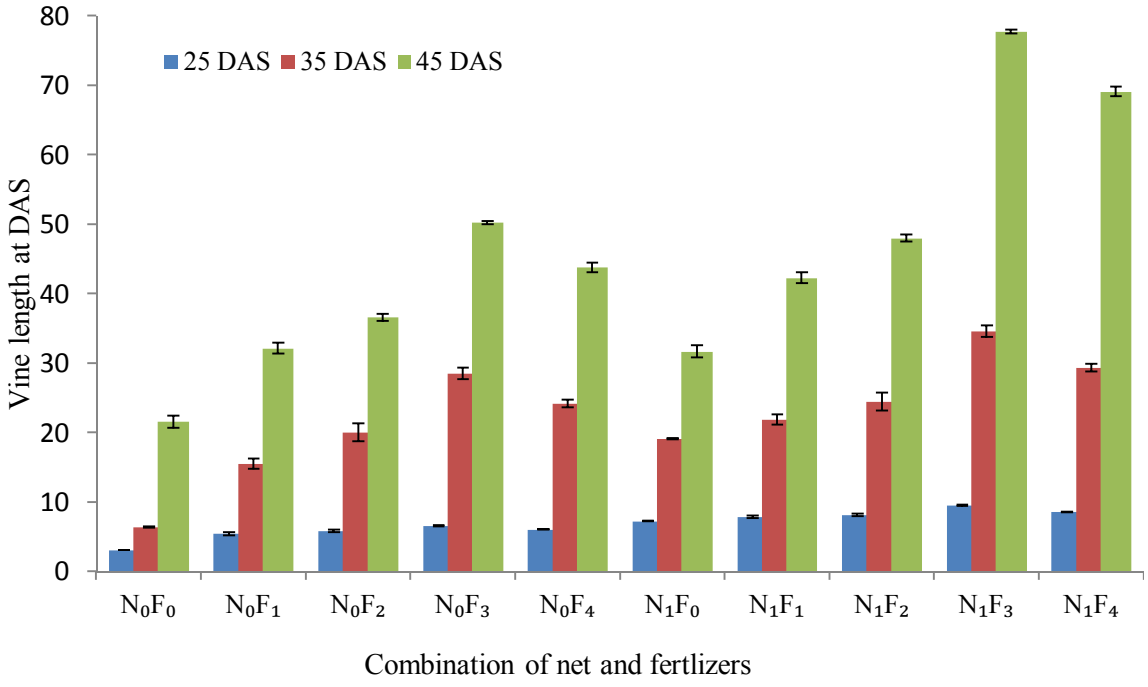

Figure 1: Combined effect of organic , inorganic fertilizers and netting on vine length of Indian spinach . Vertical bars represnt ± SE.

N_0= Control, N_1 = Netting; F_0 = Control (No fertilizer), F_1 = Vermicompost (10 t/ha), F_2 = Vermicompost (15 t/ha), F_3 = Mixed fertilizer ($2/3^{rd}$ of F_2 + $1/3^{rd}$ of F_4 treatment), F_4 = Inorganic fertilizer

The treatment combination N_1F_3show 72% and 80% highest vine length and yield compared to control. The second highest growth and yield was found from the inorganic fertilizer with net and this was 17% less production compared to mixed fertilizer with net

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(N_1F_3). Vermicompost application increased from 10 to 15 t/ha where 21% yield was increased due to increase the application of vermicompost. Mixed fertilizer promoted higher production, reduced the amount of inorganic fertilizer and improve the soil quality.

Leaf numbers and leaf length of Indian spinach at 25, 35 and 45 DAS werefound significantly different and the highest ?was found in N_1F_3 (Table 1). The second highest growth was obtained in net with inorganic fertilizer application. Comparing the sole application of inorganic or vermicompost application, improved result was found in inorganic fertilizer application. With the higher rateofvermicompostapplication growth and yield was increased in Indian spinach. This result is coherence with the result of yield (?) as leaf number, leaf length and the vine length increased higher yield. In earlier study plants grown under shade (50%) with nitrogen application showed vigorous growth and yield compared to open field (unshaded condition) in bangladhonia (*Eryngium foetidum*) [12]. Also, the highest plant height of potato was observed through the combination of vermicompost mixed with 100% NPKS (chemical fertilizers) was applied to the soil [13]. On the other hand, tomato leaves were increased by vermicompost applications [14].

Leaf numbers and leaf length were increased when the rate vermicompost application were increased from 10 to 15 ton per hectare. The sole application of inorganic fertilizer produced higher growth and yield compared with sole application of vermicompost in the soil. The higherrate ofvermicompost application resulted increased yield. It is necessary to consider the amount of volume to soil. Considering this, judicial application of organic and inorganic fertilizer is suitable for the production, quality of crop and eco-friendly. IBest performance of plant growth and yield was found from mixed of organic and inorganic fertilizer with net except the vine diameter. Vine diameter was higher in mixed fertilizer without net (Table 2).

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Table 1. Combined effects of netting and different fertilizers on leaf numbers per plantand leaf lengthat different DAS of Indian spinach

Net × Fertilizer	Leaf numbers per plant			Leaf length (cm)		
	25 DAS	35 DAS	45 DAS	25 DAS	35 DAS	45 DAS
N_0F_0	3.26 ± 0.08 f	8.14 ± 0.09 f	15.59 ± 0.13 f	3.80 ± 0.07 e	6.25 ± 0.09 g	8.22 ± 0.11 f
N_0F_1	5.80 ± 0.3 e	13.07 ± 0.26 e	28.36 ± 0.45 e	5.67 ± 0.12 d	10.40 ± 0.1 f	13.15 ± 0.2 e
N_0F_2	6.20 ± 0.2 d	14.25 ± 0.07 d	33.99 ± 0.56 d	6.09 ± 0.13 c	12.00 ± 0.2 d	16.34 ± 0.17 d
N_0F_3	6.92 ± 0.03 b	17.06 ± 0.42 b	47.14 ± 0.87 b	7.07 ± 0.08 a	13.44 ± 0.22 c	18.54 ± 0.28 b
N_0F_4	6.62 ± 0.14 c	15.37 ± 0.17 c	41.96 ± 0.09 c	6.37 ± 0.14 b	12.37 ± 0.19 c	17.18 ± 0.13 c
N_1F_0	6.54 ± 0.15 d	14.51 ± 0.14 d	25.59 ± 0.38 e	5.60 ± 0.04 d	11.32 ± 0.07 e	13.89 ± 0.28 e
N_1F_1	7.16 ± 0.22 b	15.49 ± 0.77 c	34.74 ± 0.58 d	6.04 ± 0.4 c	12.69 ± 0.25 c	16.10 ± 0.55 d
N_1F_2	7.64 ± 0.26 b	16.89 ± 0.62 b	38.80 ± 0.85 c	6.63 ± 0.19 b	14.93 ± 0.23 b	18.23 ± 0.35 d
N_1F_3	8.77 ± 0.29 a	20.48 ± 0.30 a	58.00 ± 1.25 a	7.88 ± 0.11 a	17.24 ± 0.47 a	21.49 ± 0.62 a
N_1F_4	7.92 ± 0.20 a	18.51 ± 0.54 a	49.59 ± 0.67 b	6.86 ± 0.16 b	15.70 ± 0.35 b	19.37 ± 0.33 b

Mean value ±SE followed by non-similar letters within a parameter are significantly different at $p<0.05$ according to Tukey's test.

DAS = Days after sowing; N_0= Control, N_1 = Netting; F_0 = Control (No fertilizer), F_1 = Vermicompost (10 t/ha), F_2 = Vermicompost (15 t/ha), F_3 = Mixed fertilizer ($2/3^{rd}$ of F_2 + $1/3^{rd}$ of F_4 treatment), F_4 = Inorganic fertilizer.

The best performance on growth and yield findings are in line with study reported on cabbage where thighest growth and yield was higher from the $2/3^{rd}$ organic fertilizer mixed with $1/3^{rd}$ inorganic fertilizer [7-8]. Also, higher yield increased was found invermicompost applications in lettuce and *Amaranthus*[15-16]. The higher yield from the mixed fertilizerprovided nutrient supply to crop. Inorganic fertilizers provide rapid release of nutrients and organic fertilizer (vermicompost) supply macro and micronutrients slowly for the plant. Vermicompost application in soil increased their microbial biomass and the dehydrogenase activity. Humic acids and others plant growth influencing substances such as plant hormones produced by microorganisms during vermicomposting and produced after microbial biomass and activity in soil, ultimately increase the growth and yield of crop [17]. This finding has potential to reduce applications of inorganic fertilizer to improve soil quality, and sustainable production of crops. Higher production of spinach was obtained in colored shade nets such as red, green, black, white along with control [18], which support the result of the present study. In our study mixed or combined fertilizer with net gave 26% higher yield compared

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open field (without net).Relative humidity (RH) and temperature were recorded inside and outside of net (data is not shown). No significant variation of RH and temperature were found from the inside and outside of net. Nevertheless, it can have some microclimatic environmental impact on the production of Indian spinach.

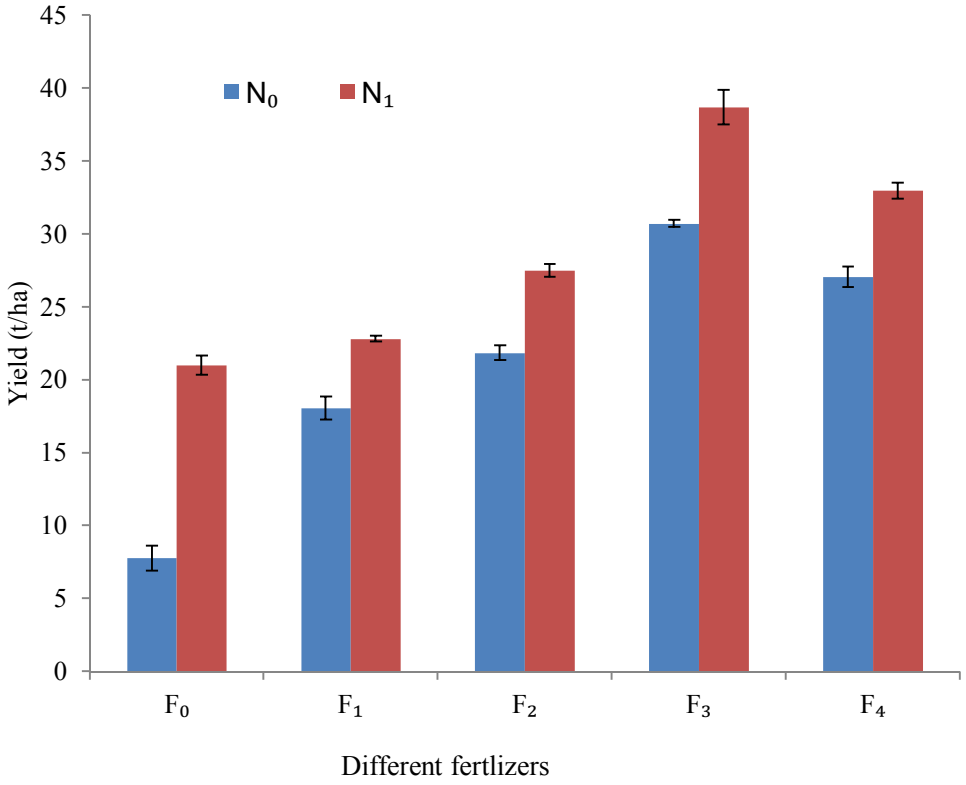

Figure 2: Combined effects of netting and different fertilizers on yield of Indian spinach. Vertical bars represent the ± SE.

N_0= Control; N_1 = Netting, F_0 = Control (No fertilizer); F_1 = Vermicompost (10 t/ha); F_2 = Vermicompost (15 t/ha); F_3 = Mixed fertilizer ($2/3^{rd}$ of F_2 + $1/3^{rd}$ of F_4 treatment); F_4 = Inorganic fertilizer

Dry matter content (%) both in leaves and stem were higher where the mixed fertilizer ($2/3^{rd}$ organic fertilizer with $1/3^{rd}$ inorganic fertilizer) with net was used (Table 2) and the second highest dry matter content was found from the inorganic fertilizer with net. Dry matter percentage of leaves is higher compared to vine. It indicates that the higher moisture percentage remain in vine compare to leaves and stems are soft and succulent is suitable for consumption.

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Table 2. Combined effects of netting and different fertilizers on vine diameter and dry matter content in the leaves and vine of Indian spinach

Net × Fertilizer	Vine diameter at 45 DAS	Dry matter percent in leaves	Dry matter percent in vine
N_0F_0	0.74 ± 0.005 f	6.12 ± 0.07 f	3.81 ± 0.13 g
N_0F_1	0.97 ± 0.014 e	12.57 ± 0.19 e	5.93 ± 0.17 f
N_0F_2	1.31 ± 0.018 b	14.45 ± 0.23 d	6.41 ± 0.45 e
N_0F_3	1.47 ± 0.05 a	20.40 ± 0.11 b	8.14 ± 0.57 b
N_0F_4	1.03 ± 0.035 d	15.73 ± 0.09 d	6.85 ± 0.16 d
N_1F_0	0.65 ± 0.012 f	15.45 ± 0.07 d	7.17 ± 0.23 c
N_1F_1	0.97 ± 0.024 e	17.87 ± 0.10 c	7.73 ± 0.59 b
N_1F_2	1.13 ± 0.017 c	19.93 ± 0.20 b	8.18 ± 0.16 b
N_1F_3	1.22 ± 0.016 b	27.97 ± 0.11 a	9.89 ± 0.45 a
N_1F_4	1.03 ± 0.017 d	21.60 ± 0.15 b	8.15 ± 0.43 b

Mean value ±SE followed by non-similar letters within a parameter are significantly different at $p<0.05$ according to Tukey's test.

DAS = Days after sowing; N_0= Control; N_1 = Netting, F_0 = Control (No fertilizer); F_1 = Vermicompost (10 t/ha); F_2 = Vermicompost (15 t/ha); F_3 = Mixed fertilizer ($2/3^{rd}$ of F_2 + $1/3^{rd}$ of F_4 treatment); F_4 = Inorganic fertilizer

4. Conclusions

This experiment conclude that the application of combined fertilizer ($2/3^{rd}$ of F_2 + $1/3^{rd}$ of F_4 treatment)with net showed the highest yield than the control treatment showed the lowest result. Mixing of organic and inorganic fertilizers has the potential to enhance yield in Indian spinach and to reduce the quantity and doses of inorganic fertilizer to improve the soil quality and environment.

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Author Contributions: Mst. Mishu Akther designed field experiment, conducted data analysis and prepared manuscript. Md. Ashraful Islam supervised during all over research work like designed field experiment, data analysis, manuscriptpreparation. Md.Saidee Rahman assisted in the field data collection.MR Karim assisted in manuscript review. D. Nandwani supervised the project overall.

Conflicts of Interest: The authors declare no conflict of interest.

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