Effect of *Nostoc commune* on Growth of *Abelmoschus esculentus* (L.) Moench

Nu Nu Tin[1], Theingi Htay[2], Sandar Htun[3] and Myint Myint Thin[4]

Abstract

In this research, the growth of *Abelmoschus esculentus* (L.) Moench (okra) were tested with *Nostoc* fertilizer. The seeds of okra were tested with *Nostoc commune* (Vaucher) Bornet in laboratory and pot culture. The okra seeds (KIRTI O14 F_1) were obtained from Myanmar Agricultural Shop, Shwebo Township, Sagaing Region. *Nostoc commune* were collected from natural habitats from Min Ywar village in southern part of Shwebo. The experiments were conducted in Department of Botany, Shwebo University from October, 2017 to September, 2018. The seeds of *Abelmoschus esculentus* (L.) Moench were treated with different suspension of *Nostoc commune* (Vaucher) Bornet ($1gl^{-1}$) for treatment $1(T_1)$, $2gl^{-1}$ for treatment $2(T_2)$, $3gl^{-1}$ for treatment 3 (T_3) and $4gl^{-1}$ for treatment $4(T_4)$ in laboratory and pot experiment. In laboratory experiment, the shoot lengths were measured at 5 days interval for 3 times. Being the treatments, treatment 1 was the best for shoot length of okra. In pot experiments, the vegetative characters were done at 14 days interval for 5 times and the data for yield characters of okra were collected at 10 days interval for 5 times. After the experiments, treatment 1 was also the best for vegetative and yield characters in pot experiments. Therefore, it was observed that the okra plants treated with *Nostoc commune* showed that excellent result in the vegetative and yield characters.

Introduction

Biofertilizers are commonly called microbial inoculants which are capable of mobilizing important nutritional elements in the soil from non-usable to usable form by the crop plants through their biological processes. Human depend on plants as food, clothing, shelter and medicines, since their existences on the earth. The needs for their survival are mainly obtained from plants.

This research is done for the increasing of yield characters by *Nostoc commune*. In Myanmar, Shwebo region is well known to its distinguished regional products such as vegetables, legumes and cereals. Shwebo is situated in Sagaing Region of central Myanmar. It located at 22˚ 34′ 53.724″ N and 95˚ 44′ 18.572″ E. An average temperature of month ranging 29.1˚ C to 36.3˚ C and the climate is tropical. The rainy season is not prolonged and the area receives less rain fall. The average rainfall for the year is 107.1 cm. It has 76.08 % of relative humidity. The elevation is 111 m above sea level. The pH value of soil is 7.3 and slightly alkaline.

Abelmoschus esculentus (L.) Moench, native is of New World tropics (Yamamoto and Nawata, 2008). *A. esculentus* is mainly cultivated in home gardens, is often used fresh for seasoning foods in the daily diet and has become an important.

Okra is most popular vegetable with fibrous fruits. Okra is mainly grown for its young immature fruits, which are consumed as a vegetable, raw, cooked or fried.

Fertilizers increase efficiency and obtains better quality of product recovery in agricultural activities. It is one of the most important ways. Fertilizers are substances added to soil to improve its fertility, and promote the growth and yield of plants. There are two kinds of fertilizers; chemical and biofertilizer (Rhykka, 2011).

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Biofertilizers are renewable and eco-friendly and more cost-effective than chemical fertilizers. Algae are important members of the plant world and several of them are significant to man in many ways.

*Nostoc*is a pioneer organism which can photosynthesize, fix atmospheric nitrogen, and secrete polysaccharides. *Nostoc commune* can also maintain soil moisture. Soil moisture is an important factor in determining the quantity and activity of soil biota. Soil-borne organisms are very active at a soil moisture content of the field capacity.

The main aim of this research were to produce organic crop, used by biofertilizer to increase in yield of okra, to improve the crop in term of higher yield. Okra has economic value and various used for food. Every country including Myanmar, cultivated the okra in different areas. *Nostoc* was tested as biofertilizer instead of chemical fertilizers. Therefore, the present study was carried out effect of *Nostoc* biofertilizers on germination, growth and yield of *Abelmoschus esculentus* (L.) Moench (okra).

Materials and Methods

The research work was conducted from October, 2017 to March, 2018 in area of Shwebo University campus. The family of the collected specimen was determined by using key to the family, Hutchinson, 1967. Identification of genera and species carried out by referring the available literatures such as floral of celonvol (Dassanayake, 1987).

Laboratory experiment

In the present study, laboratory room-culture experiment was conducted at Department of Botany, Shwebo University. The okra seed were obtained from Myanmar Agricultural Shop, Shwebo Township (fig.1). This research is carried out from October to November, 2017 at the Department of Botany, Shwebo University. The plastic petridishes 3.5cm in height and 12.3cm in diameter were used in this experiment. *Nostoc* powder were weighted by analytical balance, Model: PA 214 (such as1g, 2g, 3g and 4g) except control condition. *Nosto*c powder were dissolved in pure water for 24 hours, and *Nostoc* suspensions (such as $T_1=1g^{-1}$,$T_2=2gl^{-1}$,$T_3= 3g^{-l}$ and $T_4=4gl^{-1}$) were tested (fig-2).

The okra seeds were soaked in different concentration of *Nostoc* suspension for 15 hours, and control were soaked in pure water. After treatments fourty seeds were placed on moist filter paper in each Petridis according to different treatments of *Nostoc* suspensions and control. The dishes were covered with lids to prevent from drying, and placed at room temperature ($30^{\circ} – 35^{\circ}$ C) in natural condition. The experimental design was arranged in Randomized Complete Block Design (RCBD) with five replications. Twenty milliliter of water was added to each Petridis to get moisture. Each Petridis was regularly water with 20ml once a day. The shoot and root length (cm) were measured in 5 DAS at first time and then 10DAS and 15DAS respectively. Data were analysed by using student “t" test (Jim *et al*, 1992).

Pot experiment

Pot experiments were conducted from November, 2017 to March, 2018 at the Department of Botany, Shwebo University.The soil 24.495kg was prepared in the bag which is 30cm in diameter and 33cm in depth and soil type is loamy. Before sowing the okra seeds were in different concentration such as *Nostoc* powder $1gl^{-1}$ for treatment 1(T_1), *Nostoc* powder $2gl^{-1}$ for treatment 2(T_2), *Nostoc* powder $3gl^{-1}$ for treatment 3 (T_3) and *Nostoc* powder $4gl^{-1}$ for treatment 4 (T_4) for 15 hours (fig.2). Then, these seeds were sown in the moist soil of each pot according to different treatments of *Nostoc* suspension. Purified water was used for control. The okra seeds were planted at a depth of about 2cm in pot using 2 seeds per pot,and the pots were placed under same condition. The experimental design was Randomized Complete Block Design (RCBD) with five replications (fig- 3).Each pot was watered daily with 5 liters to maintain moisture at field capacity. Plant height, number of leaves and width were measured at14 days interval respectively.The length,weight and number of fruit were collected on all plant on 10 days interval from 10DAS to 20,30,40 and 50 DAS (Days After Sowing).

All data recorded for growth and yield characters of okras were analyzed statically for Analysis of Variance (ANOVA) to determine the significant difference by using IRRI (International Rice Research Institute) stat (version 0.5) software and program was used. The least significant difference (LSD) test method, at 5% and 1% level of significance were used to verify the significance of differences among treatment means.

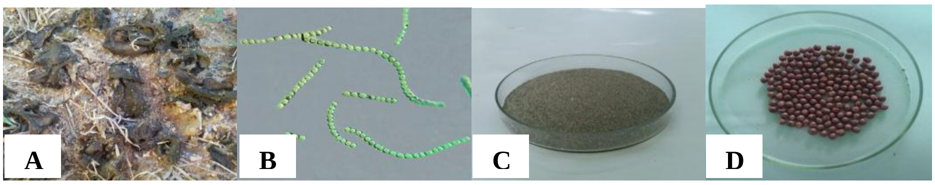

Fig 1**. Materials used in this experiment**

A. *Nostoc commune* (Vaucher) Bornet in natural habitat
B. Microscopic structure of *Nostoc commune* (Vaucher) Bornet
C. *Nostoc* powder
D. Okra seeds

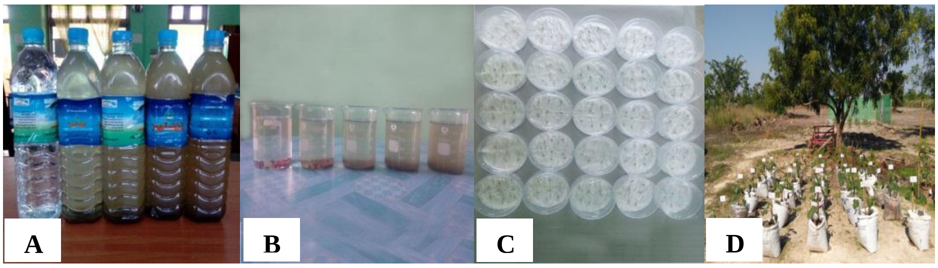

Fig 2. Preparation of *Nostoc* suspension, soaking seeds in control and treatments with *Nostoc* suspension and preparation of experimental design

A. *Nostoc* suspension
B. Soaking seeds in control and treatments with *Nostoc* suspension
C. Preparation of experimental design in laboratory
D. Preparation of experimental design in pots

Results

In this study, the effects of *Nostoc* suspension (1 gl^{-1}, 2 gl^{-1}, 3 gl^{-1} and 4 gl^{-1}) on the growth rate of *Abelmoschus esculentus* (L.) Moench are tested in laboratory and pot culture.

1. Laboratory experiment

1.1 Shoot Characters

The effect of *Nostoc* suspension treatments on shoot length of *Abelmoschus esculentus* (L.) Moench was shown in (Table-1, Fig-4, 5). In this result, the mean shoot length in treatment 4 was 7.12cm but control was 3.45 cm at 5 days after sowing. The mean shoot length in treatment 1 was 11.36cm but control was 7.26cm at 10 days after sowing.The mean shoot length in treatment 1 was 12.42cm but control was 7.98cm at 15 days after sowing. When comparison on shoot length of *Abelmoschus esculentus* (L.) Moench at 5 days after sowing, treatment 1 was not significantly difference from each other at 5% and 1% level respectively (Table-2). In the shoot length of 10 days old plants, treatment 1 was significantly difference from other treatment and control but treatment 3 was not significantly difference from control at 5% and 1% level respectively (Table-3) .When comparison on shoot length of 15 days old plant, showed that the treatment 1 highly significant different from other treatment and control at 5% and 1% level respectively (Table-8).

2. Pot experiments

2.1 Shoot characters

2.1.1 Plant height (cm)

When comparison on plant height of 14 days and 42 days old plants, T_1 treament possessed highest plant height having 6.30 cm and 30.65 cm.They were significantly different from control at 5% level but was not significantly different from other treaments.In 56 days and 70 days old plant, T_1 treament singnificantly different from control at 1% and 5% level. T_1 treament of 56 days old plant was significantly different from other treament at 5% level(Table-5, fig-6,7,8).

2.1.2 Plant width (cm)

The data collection in 14 ,28, 42, 56 and 70 days after sowing showed that the width of plant in treament 1 were more than that of other treatment and control. The width of plant affected by all treatments were non significant from each other at collection times (Table- 6, fig-6, 7, 8).

2.1.3 Number of leaves per plant

The T_1 treament possessed highest mean number of leaves 5.10, 7.30, 9.20, 12.30 and 14.60 while control possessed lowest mean number of leaves 2.60, 4.20, 5.80, 8.10 and 10.10 at 14, 28, 42, 56 and 70 days after sowing respectively. Thus, the mean leaves number of all treaments were higher than control significantly different at 5% level on all collection dates (Table- 7, fig-6,7,8).

2.2 Yield Characters

2.2.1 Number of Fruit per plant

Number of fruits,one of the yield characters in vegetable were also observed.T_1 treatment possessed highest number of fruits having 2.80 followed by 4.20, 3.30,2.70 and 2.30 at 56, 66, 76,86 and 96 days after sowing respectively. While control possessed the lowest number of fruits having 1.00, 2.00, 1.40, 1.00 and 0.60 at 56, 66, 76, 86 and 96 days respectively. Biofertilizer treament 1 has significantly different at 5% level in 56, 66, 76 and 96 days after sowing with control (Table- 8, fig-9).

2.2.2 Fruit length (cm)

When comparison on fruit length of 56, 86 and 96 days old plant, showed significantly different from control at 5% level respectively. But, the fruit length of 66 and 76 days old plants, T_1 treament and control were not significantly different from each other (Table-9, fig-9).

2.2.3 Fruit weight (g)

The mean fruit weight in T_1 (29.81g) was the best and followed by T_2 (26.52g), T_4 (23.07g), T_3 (23.04g) and control (20.47g). The mean fruit weight in T_1 was higher than T_2, T_3, T_4 and control in 66 days after sowing. When T_1 treament was significantly different from control at 1% and 5% level in 66 days after sowing. In 76, 86 and 96 days old plants, all treaments and control were not significantly different at 1% and 5% level (Table- 10, fig.9).

Table 1. Effect of *Nostoc* suspension on mean shoot length (cm) of *Abelmoschus esculentus* (L.) Moench in laboratory experiments

Treatments and control	5DAS	10 DAS	15 DAS
	Mean ± S.D	Mean ± S.D	Mean ± S.D
C	3.45 ± 0.95	7.26 ± 4.71	7.98 ± 4.74
T_1	5.32 ± 2.62	11.36 ± 5.02	12.42 ± 5.04
T_2	5.40 ± 2.32	9.46 ± 3.49	8.87 ± 4.25
T_3	6.09 ± 2.49	10.52 ± 3.41	11.97 ± 3.43
T_4	7.12 ± 3.17	9.25 ± 3.22	9.60 ± 3.47

DAS = Days After Sowing
C = Control (untreatment)
T_1= $1gl^{-1}$ (*Nostoc* suspension)
T_2 = $2gl^{-1}$ (*Nostoc* suspension)
T_3 = $3gl^{-1}$ (*Nostoc* suspension)
T_4 = $4gl^{-1}$ (*Nostoc* suspension)

Table 2. Comparison on shoot length (cm) of *Abelmoschus esculentus* (L.) Moench at 5 DAS in laboratory experiments

Nostoc suspension treatment (gl^{-1})	C	T_4	T_3	T_2
T_1	t = 1.14 n.s	1.6 n.s	1.38 n.s	0.9 n.s
T_2	t =1.10 ns	1.58 ns	1.55 n.s	
T_3	t = 1.20 n.s	1.64 n.s		
T_4	t = 1.44 n.s			

Table 3. Comparison on shoot length (cm) of *Abelmoschus esculentus* (L.) Moench at 10 DAS in laboratory experiments

Nostoc suspension treatment (gl^{-1})	C	T_4	T_3	T_2
T_1	t = 2.43**	2.55**	2.68**	2.62**
T_2	t = 2.16**	2.29**	2.44**	
T_3	t = 1.73 n.s			
T_4	t = 2.07*			

Table 4. Comparison on shoot length (cm) of *Abelmoschus esculentus* (L.) Moench at 15 DAS in laboratory experiment.

Nostoc suspension treatment (gl^{-1})	C	T_4	T_3	T_2
T_1	t = 2.62**	2.68**	2.79**	2.72**
T_2	t = 2.34**	2.40**	2.53**	
T_3	t = 2.42**	2.48**		
T_4	t = 2.30**			

't' = t value
n.s = non significant
*, ** = significantly different at 5% and 1% level respectively
C = control
T_1 = Treatment 1
T_2 = Treatment 2
T_3 = Treatment 3
T_4 = Treatment 4

Table 5. Effect of *Nostoc* fertilizer on plant height(cm) of *Abelmoschus esculentus* (L.) Moench in pot experiments

Treatments	Plant Height (14 DAS)	Plant Height (28 DAS)	Plant Height (42 DAS)	Plant Height (56 DAS)	Plant Height (70 DAS)
C	3.59	11.20	23.33	36.74	43.42
T_1	6.30	14.20	30.65	48.80	56.51
T_2	5.67	12.55	29.68	46.25	49.88
T_3	5.80	12.70	29.38	46.62	46.13
T_4	5.80	12.65	29.50	48.22	54.02
F	**	*	*	*	*
CV%	14.07	15.56	18.91	21.09	20.86
LSD 0.05%	2.79	4.24	6.36	8.03	8.39
LSD 0.01%	3.97	6.04	9.04	11.42	11.94

Table 6 . Effect of *Nostoc* fertilizer of plantwidth(cm)of *Abelmoschus esculentus* (L.) Moench in pot experiments

Treatments	Plant Width (14 DAS)	Plant Width (28 DAS)	Plant Width(42 DAS)	Plant Width(56 DAS)	Plant Width (70 DAS)
C	0.56	1.11	2.03	2.56	2.78
T_1	0.68	1.55	2.31	2.78	3.01
T_2	0.71	1.49	2.20	2.75	3.02
T_3	0.69	1.46	2.47	2.69	3.13
T_4	0.69	1.59	2.36	2.79	3.10
F	ns	*	ns	ns	ns
CV%	17.66	25.98	16.48	14.29	12.86
LSD 0.05%	0.98	1.45	1.80	1.96	2.06
LSD 0.01%	1.39	2.06	2.57	2.79	2.93

Table7. Effect of *Nostoc* fertilizer on number of leaves of*Abelmoschus esculentus* (L.) Moenchin pot experiments

Treatments	No. of leaves (14 DAS)	No. of leaves (28 DAS)	No. of leaves (42 DAS)	No. of leaves (56 DAS)	No. of leaves (70 DAS)
C	2.60	4.20	5.80	8.10	10.10
T_1	5.10	7.30	9.20	12.30	14.60
T_2	4.60	6.50	7.20	11.20	13.00
T_3	4.00	6.70	8.00	11.80	13.40
T_4	4.20	6.60	7.90	11.40	13.60
F	**	**	**	**	**
CV%	21.46	18.49	18.37	17	14.22
LSD 0.05%	2.46	3.01	3.32	3.39	4.30
LSD 0.01%	3.50	4.28	4.72	5.64	6.11

Table 8. Effect of *Nostoc* fertilizer on number of fruit per plant of *Abelmoschus esculentus* (L.) Moenchin pot experiments

Treatments	No. of fruits (56 DAS)	No. of fruits (66 DAS)	No. of fruits (76 DAS)	No. of fruits (86 DAS)	No. of fruits (96 DAS)
C	1.00	2.00	1.40	1.00	0.60
T_1	2.80	4.20	3.30	2.70	2.30
T_2	2.20	3.70	2.50	2.30	2.00
T_3	2.40	3.80	2.30	2.30	2.10
T_4	2.60	3.90	2.60	2.40	2.20
F	**	**	**	**	**
CV%	21.32	23.76	20.66	23.81	21.74
LSD 0.05%	1.80	2.27	1.89	1.78	1.67
LSD 0.01%	2.57	3.32	2.69	2.54	2.38

Table 9. Effect of *Nostoc* fertilizeron fruit length (cm) of *Abelmoschus esculentus* (L.) Moench in pot experiments

Treatments	Fruit Length (56DAS)	Fruit Length (66 DAS)	Fruit Length (76 DAS)	Fruit Length (86 DAS)	Fruit Length (96 DAS)
C	9.30	10.89	12.80	9.07	8.76
T_1	13.50	14.02	13.40	13.07	12.67
T_2	13.20	13.50	12.42	12.61	11.26
T_3	12.80	13.53	12.62	12.36	11.64
T_4	13.02	13.61	13.00	12.41	11.80
F	**	**	ns	**	**
CV%	11.39	11.26	11.24	13.45	16.59
LSD 0.05%	4.20	4.31	4.26	4.00	3.91
LSD 0.01%	5.97	6.13	6.05	5.86	5.69

Table 10. Effect of *Nostoc* fertilizer on fruit weight (g) of *Abelmoschus esculentus* (L.) Moenchin pot experiments

Treatments	Fruit Weight (56 DAS)	Fruit Weight (66 DAS)	Fruit Weight (76 DAS)	Fruit Weight (86 DAS)	Fruit Weight (96 DAS)
C	6.29	20.47	12.88	11.35	8.54
T_1	9.83	29.81	17.58	16.12	13.19
T_2	9.30	26.52	16.18	15.45	12.61
T_3	9.39	23.04	16.91	14.80	12.52
T_4	9.67	23.07	17.24	15.48	12.77
F	**	**	*	*	**
CV%	20.53	19.79	20.65	20.98	23.14
LSD 0.05%	3.59	5.94	4.81	4.59	4.16
LSD 0.01%	5.10	8.45	6.84	6.53	5.92

*, ** = Significantly different at 5% and 1% level respectively:
ns = non significant
LSD(0.05) = Least Significant Differences
LSD (0.01) = Least Significant Differences
CV = Coefficient of variance percent

C = control (untreatment)
T_1 = $1gl^{-1}$(*Nostoc* suspension)
T_2 = $2gl^{-1}$ (*Nostoc* suspension)
T_3 = $3gl^{-1}$(*Nostoc* suspension)
T_4 = $4gl^{-1}$ (*Nostoc* suspension)

Fig 3. **Morphological characters of *Abelmoschus esculentus* (L.) Moench**

A. Habit B. Inflorescences C. Fruits

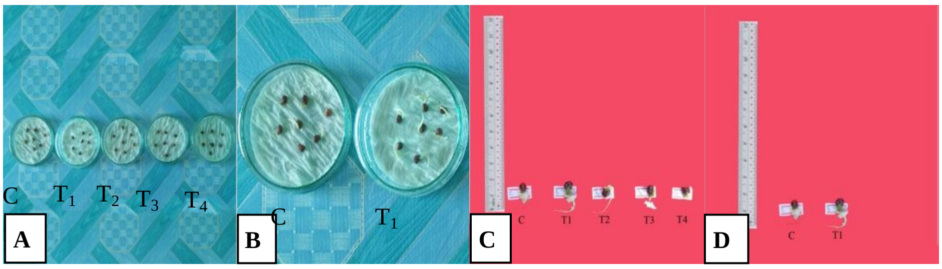

Fig 4. **Effect of *Nostoc* suspension on germination and seedling growth of *Abelmoschus esculentus* (L.) Moench**

A. Germination of control and treatments C. Seedling of control and treatments (5 DAS)
B. Germination of control and treatment 1 D. Seedling of control and treatment 1 (5 DAS)

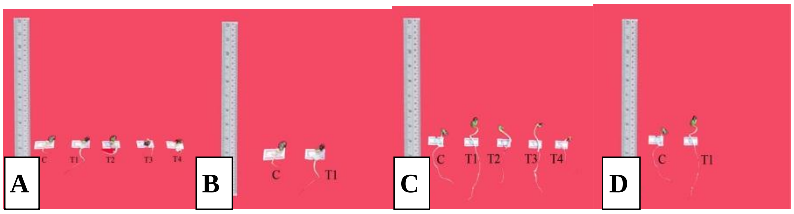

Fig 5. **Effect of *Nostoc* suspension on seedling growth of *Abelmoschus esculentus* (L.) Moench**

A. control and treatments (10 DAS) C. control and treatments (15 DAS)

B. control and treatment 1 (10 DAS) D. control and treatment 1 (15 DAS)

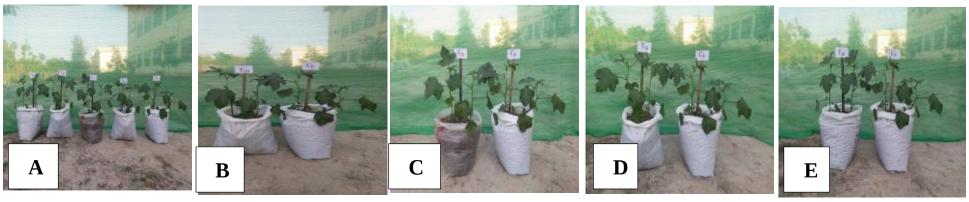

Fig 6. Effect of *Nostoc commune* (Vaucher) Bornet on *Abelmoschu sesculentus* (L.) Moench in pot experiments

A. Control and treatments (42 DAS) D. Control and treatment 3 (42 DAS)

B. Control and treatment 1(42 DAS) E.

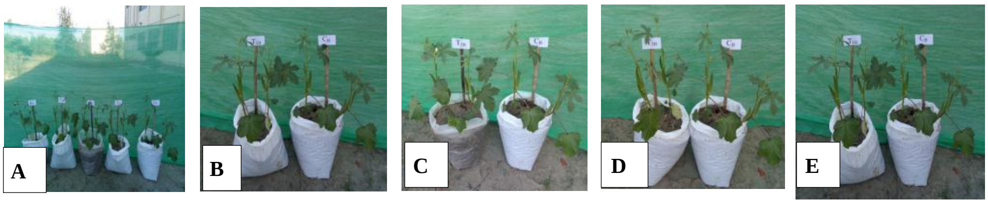

Fig 7. Effect of *Nostoc commune* (Vaucher) Bornet on *Abelmoschus esculentus* (L.) in pot experiments

A. Control and treatments (56 DAS)
B. Control and treatment 1 (56 DAS)
C. Control and treatment 2 (56 DAS)
D. Control and treatment 3 (56 DAS)
E. Control and treatment 4 (56 DAS)

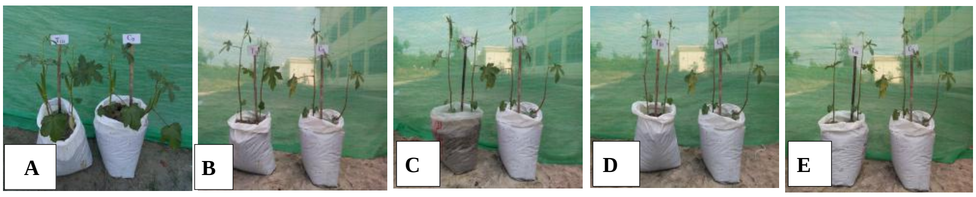

Fig 8. Effect of *Nostoc commune* (Vaucher) Bornet on *Abelmoschus esculentus* (L.) Moench in pot experiments

A. Control and treatments (70 DAS) D. Control and treatment 3 (70 DAS)

B. Control and treatment 1 (70 DAS) E.

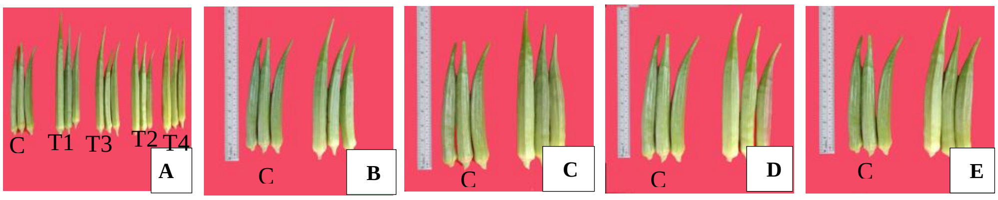

Fig 9. Effect of *Nostoc* suspension on fruits of *Abelmoschus esculentus* (L.) Moench in pot experiments

A. Control and treatments
B. Control and treatment 1
C. Control and treatment 2
D. Control and treatment 3
E. Control and treatment 4

Discussion and Conclusion

Shwebo area was selected and studied for this research. This paper mentioned the effect of *Nostoc commune* (Vaucher) Bornet on the growth rate of okra.

Plants contain different chemical compounds which used for human life. Industry and agricultural products are dependent on plants for many of its chemical compounds. Plants produce various metabolic products for their growth and development.

The species of okra is economically cultivated and abundantly in the study area. The seeds of okra were differently soaked in suspension for 24 hours in laboratory for germination only. It was found that soaked in suspension seeds were highest germination. And then, shoot and root length was measured.

In 15 old plants, the shoot length (12.42 cm) and root length (7.49 cm) were found in the treatment of *Nostoc* fertilizer suspension (1 gl^{-1}). The shoot and root length of control were 7.98 cm (Table- 1). Thus, the laboratory experiments of the present study showed that *Nostoc* fertilizer suspension had the most highest shoot and root lengthof *Abelmoschus esculentus* (L.) Moench. This results were in agreement with those stated that by Thida Aye, 2011 and Myo Myint Aung, 2014. These results are also agreed with the observation of Ashish Kumar Sahu, 2014.

In the pot experiments results of the present study showed that T_1 treatment caused a significantly increase in plant height (56.51 cm), plant width (3.13 cm) and number of leaves (14.60) of *Abelmoschus esculentus* (L.) Moench and T_1 treatment significantly increased the yield characters number of fruits (2.30), length of fruit (12.67 cm), fruit weight (13.19 g) of the okra plants, compared to those of control. Plant height (43.42 cm), plant width (2.78 cm), number of leaves (10.10), number of fruit (0.60), fruit length (8.76 cm) and fruit weight (8.54 g) (Table 5,10). These rusults are in accordance with the previous observations of Svircev*et al*., 1997, Zaccaro*et al*., 1999, Maqubela *et al*., 2009.

The present study reported that the use of *Nostoc* biofertilizers can improve plant growth and crop yield. They also add organic material to soil. The treatment of okra with *Nostoc*, increased percentages yield of *Nostoc* treated plant over the control.

So, it can be concluded that *Nostoc commune* is used as potential natural bio-fertilizer to okra. Therefore, growers should be used bio-fertilizers for okra. The results of present research will be providing that may be probably helpful and useful for the growers of study area. And then all the people in study area aware the important value of biofertilizer (*Nostoc commune*).

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