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Development of year round vegetable farming technologies on brackish water shrimp *Gher* dykes in southern Bangladesh

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Abstract: The experiment was conducted at farmers' field in a village named Parsolua under Batiaghata Upazila of Khulna district at brackish water shrimp gher agro-ecological conditions/systems under CSISA-BD project with the objectives – (a) to identify the options for round the year vegetables cultivation in saline shrimp gher dyke of southern Bangladesh; (b) to validate the technology for wider dissemination in changing climate condition; (c) to increase cropping intensity in the saline prone area; and (d) to strengthen the aquaculture-agriculture systems (as use of pond bottom mud). Variable soils used for vegetable production in the experiment consisted of bottom sludge of fresh water (S1), Dyke (gher) soil (S2) and bottom soil of brackish water gher (S3) using a two crop model (i) M1- bitter gourd & yard long bean (rainy season) and pumpkin & tomato (winter); and (ii) M2- bottle gourd and okra (rainy season). Results reveal that the highest production mass (81.59 t/ha) was produced with bottom sludge of fresh water X M1 winter (Sweet gourd/pumpkin and tomato) and the lowest production (27.85 t/ha) was found from bottom soil of brackish water gher X M1 summer (bitter gourd and yard long bean).

Key words: Year round vegetable, farming technology, brackish, shrimp, *Gher* dykes, Bangladesh

Introduction

About 30-50% of net cropped areas remain fallow in the coastal areas of Bangladesh in rabi and kahrif-1 (winter & summer) seasons, due to salinity, water logging and drought (Alauddin and Kahn, 2013; Haque S.A., 2006). Farmers continuously invest their piecemeal effort to overcome the challenges of vegetables production in unfavorable ecosystems. In southern Bangladesh approximately 60% of cultivable land is saline prone and 80% of that is under gher systems with day by day salinity intrusion increasing as a consequence of of climate change (Alauddin and Kahn, 2013). Crop production, especially of vegetables is hampered by an increasing trend of saline and a large amount of area that becomes fallow during the summer (February-June) season. In order to help to address the nutritional requirement of increasing population and simultaneously increase income and create employment opportunity for farm household members of southern Bangladesh, effective technology is needed for vegetable production in saline prone shrimp gher dyke. Shrimp gher systems have been used as the potential adaption option for climate change and increased resilience in the coastal areas (KGF 2011).

Farmers continually invest effort in the development of a copping mechanism with the changing climate situation to innovate cultivation practice for year round vegetables production in brackish water gher dyke. Efforts thus far have been unsuccessful, and as a result a large area remains unproductive.

In Southern Bangladesh (Khulna and Barisal division) there are 125,881 ha of brackish water shrimp (locally called Bagda) gher (BBS, 2011). If it is assumed that around 12,588.06 ha (10% of water body) is dyke and if 60% of this dyke can be used for vegetable cultivation, then approximately 7,553 ha dyke will be productive, adding meaningfully to national food production.

Materials and Methods

This experiment was a researcher-managed on-farm experiment conducted in a farmers' field under CSISA-BD project funded by USAID. The research site was in a village named Parsolua under Batiaghata Upazila of Khulna hub with brackish water shrimp gher agro-ecological conditions/systems, and the plots were divided into sub-plots which were 10 m long. Each main strip plot was 20 m long and the dyke was 1m wide; the study was conducted on 180 m long dyke with a 1m width. The trellis was 3 m wide from the edge of dyke and the gher was used for vine vegetable cultivation. The experiment was conducted in Randomized Complete Block Design (RCBD) with three replications.

Treatments:

Factor A: Soil type

(i) Fresh water fish pond bottom sludge (S_1): This sludge was collected from the fresh water pond, which is intensively cultured with Pangus fish. For the present study it was collected from Jhikargacha upazila of Jessore district; (ii) Gher dyke soil (S_2): This soil is not collected from the outside, using soil remaining undisturbed in the pit of study dyke; and (iii) Brackish water shrimp gher bottom sludge (S_3): This was collected from the study gher and used after drying.

Factor B: Crop (Types of Vegetables or model)

Only for summer season, there were two models, but for winter season there was a single model. The models are: (i) Model-1 (M_1): This comprises for summer (rainy/ kharif-2) season, and with combination of two vegetables for the season. The vegetable combination was Bitter gourd and Yard long bean and in winter season pumpkin and tomato (Plate-1), (ii) Model -2 (M_2):This comprises also for summer (rainy/kharif-2) season the crops was Bottle gourd and okra (Plate 2).

For winter season there was a single crop model and comprises with Pumpkin and Tomato.

Pit preparation: The pits were prepared according to crop's root systems development. For bitter gourd, pits have been prepared as 30 cm x 30 cm, for bottle gourd, sweet gourd it was 45 cm x 45 cm, and for yard long bean, okra and tomato pits was as 20 cm x 20 cm. Pits were prepared on 1st to 10th June, 2014 for summer season.

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Spacing was 2 m for bottle gourd and sweet gourd; 1m for bitter gourd, 50 cm for yard long bean, okra and tomato.

Sowing/Planting: Seeds of Bottle gourd and Bitter gourd were dibbled in a 15 cm x 10 cm poly bags with fresh water soil and poultry litter mixed media and in the 2nd week of June and seedlings then planted on 3rd week of June 2014 after germination. Okra and yard long bean seeds were directly sown in the pits on 3rd of June 2014 at 0.5m distance from one to another. Tomato was planted as seedling on 2nd week of October 2014 at 0.5m distance from one to another and Sweet gourd seedling was planted followed by Bitter gourd and Bottle gourd at 2m distance.

Plate 1. Bitter gourd, pumpkin and tomato

Plate 2. Trellies of bottle gourd

Trellis Making: Trellis was made with bamboo, coarse thread and thread net. Width of trellis is 3m and long as required and 20m long for each treatment combination.

Sticking: Sticking was been made with bamboo and thread for easy climbing of tomato, okra and yard long bean after 15 days of transplanting & sowing. All lower twigs of tomato were clipped immediately after 1st flower setting twig.

Fertilizer Application:

For Bottle gourd and Bitter gourd: Fertilizer was applied as top dressing after 1week of seedling plantation, flowering initiation stage and after 1st harvest. Fertilizer DAP@ of 1st top-dress 30g/pit, 2nd top-dress 20 g/pit and 3rd top-dress is 20g/pit for bottle gourd, and for bitter gourd 1st top-dress 20g/pit, 2nd top-dress 10g/pit, 3rd top-dress 10g/pit and gypsum only at 1sttop dress @ 20g/pit for both crops.

For Okra and Yard long bean: 5g/pit of both DAP at three time of plant life cycle as above mentioned stage and gypsum 10g/pit at 1st dose. (i.e., 1.2kg/decimal of DAP and 800g/decimal of gypsum)

For Sweet gourd: 1st top dressed at 2 week of seed germination, 2nd top dressed at flower initiation time and 3rd top dressed at 2 week of 1st fruit setting @ of DAP-30g, 20g and 20g per pit/plant; and gypsum-20g/pit at 1st, 2nd and 3rd top-dress, respectively.

For Tomato: 1st top-dressed was in 2 weeks of tomato seedling plantation, 2nd top-dressed at 1st flower blooming, 3rd top-dressed just after 1st fruit harvest and 4th top dressed after 3rd harvest. Fertilizers were DAP- 1.6kg/ decimal. (5g per plant/ top-dress), gypsum 400g/ decimal (5gm/ plant) only at 1st top-dress. Micronutrient was applied as per requirement.

Results

Main effect of soil types on production and its value: The findings showed that vegetable production in different plots was significantly influenced by main effect of soils collected from different sources like bottom sludge of fresh water -S1, Dyke (gher) soil -S2 and bottom soil of brackish water gher-S3) (Table 1). The bottom sludge of fresh water (S1) gave the highest production (93 kg per plot or 92.78 t/ha) of vegetables (bitter gourd & yard long bean, bottle gourd & okra in summer and sweet gourd &tomato in winter) which was sold by Tk. 2, 038, 356 followed by dyke (gher) soil (S2) 72.6 t/ha which was sold by Tk. 1, 623, 439 and Brackish water gher (S3) 57 t/ha which was sold by Tk.1, 254, 828.

Main effect of different cropping seasons on production and sale value: The findings in the Table 2 showed that the production of vegetables (bottle gourd & okra, bitter gourd & yard long bean, and sweet gourd & tomato) was significantly influenced by the main effect of different growing seasons (T_1= summer-Kharif 1, T2 = winter and

T_3 = summer-Kharif 2) of vegetables. The cropping season T_2 = winter gave the highest production (135.33 t/ha) of vegetable which was sold by Tk. 2,642, 722.22 followed by T_3 = summer-Kharif 2 which was sold by Tk.1,006, 544.44 and season T1= summer-Kharif 1 produced 35.81 t/ha which was sold by Tk. 1,267, 355.56. It is noteworthy that the production of T_1= summer-Kharif 1 season is the lowest but the sale value was the second highest.

Table 1. Main effect of Soil types on production and sale value of crops

Treatment	Sale value (Tk/10m^2)	Production (kg/10 m^2)	Salevalue (LacTk/ha)	Production (t/ha)
S1	2038.36	92.78	20.38	92.78
S2	1623.44	72.58	16.23	72.58
S3	1254.83	57.13	12.54	57.13
LSD 5%	116.55	16.28	11.65	5.87
LSD 1%	160.58	22.43	16.05	11.45
Level of significance	**	**	**	**

S_1= Bottom sludge of fresh water, S_2= Dyke (gher) soil, S_3= Bottom soil of Brackish water gher, ** = Significance at 1% level of probability.

Table 2. Main effect of different cropping seasons on production and sale value

Treatment	Salevalue (Tk/10m^2)	Production (kg/10m^2)	Salevalue (Tk/ha)	Production (t/ha)
T1	1267.36	35.81	12.67	35.81
T2	2642.72	135.33	26.42	135.33
T3	1006.54	51.35	10.06	51.35
LSD 5%	116.55	16.28	11.65	5.87
LSD 1%	160.58	22.43	16.05	11.45
Level of Significance	**	**	**	**

T_1 = M_1 Summer (Bitter gourd and Yard long bean (YLB), T_2 = M_1 Winter (Sweet gourd/Pumpkin and Tomato, T_3 = M_2 Summer (Bottle gourd and okra)

Table 3. Combined effect of different soil types and cropping seasons on production and sale value

Treatment	Production (kg/10m$^{2)}$	Salevalue (Tk/10m^2)	Production (t/ha)	Salevalue (LacTk/ha)
S1T1	46.50	1577.00	46.50	15.77
S1T2	81.59	1595.34	81.59	15.96
S1T3	68.68	1347.40	68.68	13.47
S2T1	33.08	1122.00	33.08	11.22
S2T2	66.25	1295.00	66.25	12.95
S2T3	52.16	1023.00	52.16	10.23
S3T1	27.85	945.00	27.85	9.45
S3T2	55.17	1082.00	55.17	107.58
S3T3	33.20	651.28	33.20	65.12
LSD 5%	10.18	201.87	10.178	20.18
LSD 1%	14.02	278.13	14.023	27.81
Level of Significance	**	**	**	**

Combined effect of different soil types and cropping seasons on production and sale value: The findings in Table 3 showed that the production of vegetables (bottle gourd, yard long bean, okra and tomato) was significantly influenced by the combined effect of different soils collected from different sources (bottom sludge of fresh water -S_1, dyke (gher) soil -S_2 and bottom soil of brackish water gher -S_3) and cropping seasons (T_1, T_2 and T_3).

The combined effect of S_1T_2 (bottom sludge of fresh water x M1 winter pumpkin and tomato) gave the highest production (81.59t/ha) of vegetable (81.59 kg per plot) which was sold by Tk. 15.96 lac followed by S1T3 (bottom sludge of fresh water pond X M_2 summer (bottle gourd and okra) with production 68.68 t/ha sold by Tk. 13.47 lac and the lowest production (27.85 t/ha) of vegetable (27.85 kg per plot) was found due to the combined effect of S_3T_1 (bottom soil of brackish water gher X M_1 summer (bottle gourd and yard long bean) which was sold by Tk. 9.45 lac.

Salinity status of soils in January to April: The salinity status of the soil types used in the research showed that the highest limit of salinity (6.10 to 8.37 ds/m) was found in the S_3 soil (bottom soil of brackish water gher) in the months of January to April (Fig. 1) but the lowest salinity (4.8 – 7.3 ds/m) was found in the S_1 soil (bottom sludge of freshwater pond). This bottom sludge was actually humus which effectively reduced the soil salinity in agreement with Wang *et al.,* (2014) resulting in more yield with S_1 treatment all the seasons: that is, application of humus (fresher water bottom sludge) could minimize the negative effect of salinity on vegetable production as reported by Celik *et al.,*(2010).

Discussion

The soils of different sources are different in their quality and nutrient status. The soils used in this experiment are of three different sources, specifically: S_1= Bottom sludge of fresh water fish pond, S_2= Dyke (gher) soil, S_3= Bottom soil of Brackish water shrimp gher.

The bottom sludge of fresh water fish pond contains higher organic matter which minimized the negative effect of saline *(*Celik *et al.*, 2014*)* and increased the fertility of saline soils (Melero *et al.*, 2007*)* that influences the fertility status rather than the S_2= Study gher dyke soil, and S_3= bottom soil of brackish water gher and gave higher yield over the other treatments. This result is in agreement with results reported by Celik *et al.,* (2014).

The above condition of the soils influenced the overall production of the vegetables cultivated (Table 1).

In Bangladesh the crop production season is mainly divided into two i.e. winter and kharif. The winter season is favorable and suitable for different vegetable production in Bangladesh. In this experiment, different vegetables like bitter gourd, yard long bean (YLB), sweet gourd/pumpkin, tomato, bottle gourd and okra were grown but seasonal conditions favored the highest production was found in T_2 = M_1 Winter (Sweet gourd/Pumpkin and Tomato) (Table 2).

In winter, as the production of sweet gourd/pumpkin and tomato was the highest (135/33 t/ha.) and unit price of tomato was higher, the collective sale value of the products was also the highest.

The soil type and cropping season both have positive influences on production and sale value of vegetables. In the experiment, we also found that the soil S_1 (bottom sludge of fresh water) and cropping season T_2 (winter) gave the most favorable result (both in value and production individually; see Table 1 and Table 2). The combined effect of soil types and cropping season S_1T_2 (bottom sludge of fresh water X M_1 winter; sweet gourd/pumpkin and tomato) also gave the highest result regarding production and sale value of the vegetables (Table 3).

Salinity status of the soil depends on the soil chemistry as well as external factor(s) involved with the soil. The soils used in the experiment were of different sources (S_1 = bottom sludge of fresh water pond, S_2 = dyke soil of gher and S_3 = bottom soil of brackish water gher) which have different salinity status. It was found that salinity increased during March and April because of increment of temperature, evaporation of water from soil (Fig.1); this may hamper production and impair plant health resulting in reduced crop production. Other researchers also supported the results of present findings (Alauddin, 2014; Hossian, 2015 and Anonymous, 2000).

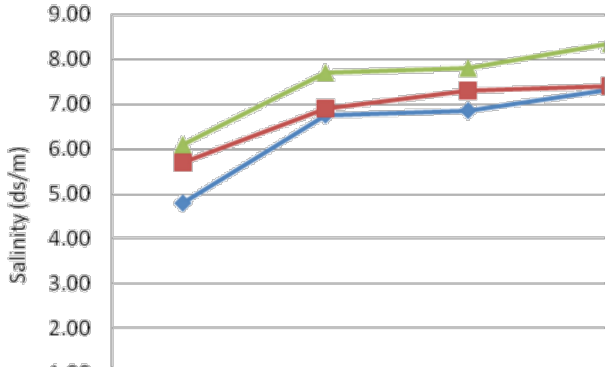

Fig. 1. Salinity status of the soils in the months of January to April

Based on the results of the studies conclusions may be drawn as: (i) Bottom sludge of freshwater pond is the most suitable for vegetable cultivation, (ii) Dyke soil of gher could be used for vegetable cultivation in absence of bottom sludge of freshwater pond/gher during wet season, (iii) Bottom soil of brackish water gher should be avoided or used with reduced expectations for vegetable cultivation, and (iv) The salinity status of bottom soil of brackish water gher is the highest compared with other soils.

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