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PRODUCTION POTENTIAL OF SWEET POTATO BASED INTERCROPPING SYSTEM IN SYLHET REGION

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Abstract

A field experiment was conducted during two consecutive years 2017-18 and 2018-19 at farming system research and development (FSRD) site, under South Surma Upazilla of Sylhet in Bangladesh to find out the suitable crop combination for increasing total productivity, return and maximizing land utilization through intercropping. Five treatments viz. T_1: Sweet potato + red amaranth, T_2: Sweet potato + leaf amaranth, T_3: Sweet potato + mustard green, T_4: Sweet potato + mustard and T_5: Sweet potato sole (100% sweet potato) were considered in the experiment. Results showed none of the intercrop-combination influenced the root yield of sweet potato. Tuberous root yield of sweet potato in 100% sweet potato + 100% mustard green combination was at per sweet potato sole cultivation. Sweet potato yield did not reduce significantly due to intercropping. The highest sweet potato equivalent yield (41.75 t ha^{-1}), land equivalent ratio (1.37), gross return (Tk. 625950 ha^{-1}), gross margin (Tk. 495500 ha^{-1}) and benefit cost ratio (4.80) were recorded from sweet potato 100% + mustard green 100% combination. On the contrary, sweet potato sole gave the lowest sweet potato equivalent yield (30.60 t ha^{-1}), gross margin (Tk.330300 ha^{-1}) and benefit cost ratio (3.57). The results revealed that sweet potato 100% + mustard green 100% intercropped combination might be suitable for higher productivity and economic return.

Keywords: Land use efficiency, production potential, sweet potato based intercropping, economic benefit.

Introduction

Sweet potato (*Ipomoea batatas*L.) is one of the most important tuber crops in Bangladesh which can be used as substitute of cereal crops to meet up the food shortage. The foliage of sweet potato has the potential for use as vegetable and animal feed (Otoo *et al*., 2001). It is the fourth important crop in Bangladesh after rice, wheat and potato (Hossain and Hakim, 2014). The orange fleshed sweet potato has significant antioxidant activity, and can potentially improve vitamin-A status in children under malnutrition (Away *et al.* 2013; Li and Mu, 2012; Burri, 2011). At present sweet potato becoming promising root crops successfully growing and disseminating in Sylhet region due to its market demand and nutritional benefits (Nazrul, 2019). Vegetables playa significant role in human nutrition, especially as sources of phytonutriceuticals: vitamins (C, A, B1, B6, B9, E), minerals and dietary fiber (Craig and Beck, 1999; Wargovich, 2000). So,

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growing a high calorie food sweet potato with vegetables viz. red amaranth, leaf amaranth, mustard green, mustard and radish etc. would ensure the supply of more dietary carbohydrates, vitamins and minerals of the rural populace.

In Sylhet region, the farmers are generally growing sweet potato as a sole crop; as it is a long durated crop (150-180 days) and cultivating with maintaining the spacing of 60 cm × 30 cm. So, there is a great scope to cultivate short durated (35-40 days) leafy vegetable in the inter row space of sweet potato. Besides, multiple cropping systems ensure proper utilization of resources towards increased production per unit area and time (Ahmad *et al.,* 2007). Vegetable crop failures are common under unfavorable climate, increases of pest and disease problems are common, which are affecting the market volatility.Intercropping is one of the viable technologies to reduce the risk of biotic and abiotic stress. Considering the above facts, this trial was undertaken tofind out the suitable crop combination for intercropping with sweet potato increasing productivity, economic returnand maximize land utilization.

Materials and Methods

The field trial was carried out during two consecutive years 2017-18 and 2018-19 at farming system research and development (FSRD) site, under South Surmal Upazilla of Sylhet in Bangladesh. The soil of experimental plot was clay loam in texture and pH ranges 5.5-6.10, organic matter 1.05%, total nitrogen 0.059%, available phosphorus 10 µg/ml, available potassium 0.12 meq/100 g soils, sulphur14 µg/ml, boron 0.30 µg/ml and zinc 1.7 µg/ml.

The monthly mean maximum and minimum air temperature and rainfall during the study period (November-March) are presented in Figure 1. The highest amount of average monthly rainfall occurred in March (286.45 mm) followed by February (87.4 mm), December (60.95 mm) and November (21.5 mm). The crops received total rainfall of 456.30 mm during crop growing period. The mean monthly maximum air temperature of 33.3^0C and minimum temperature of 9.15 ^{0}C were recorded during crop season.The climatic data of Sylhet shows that the monthly average minimum temperature is 9.15 °C and the mean maximum temperature is 33.3 °C.

Five treatments combinations viz. T_1: Sweet potato + red amaranth, T_2: Sweet potato + leaf amaranth, T_3: Sweet potato + mustard green, T_4: Sweet potato + mustard and T_5: Sweet potato sole (100% sweet potato) were considered in the experiment. The experiment was setup in a randomized complete block design with three replications. The unit plot size was 8 m × 5 m.

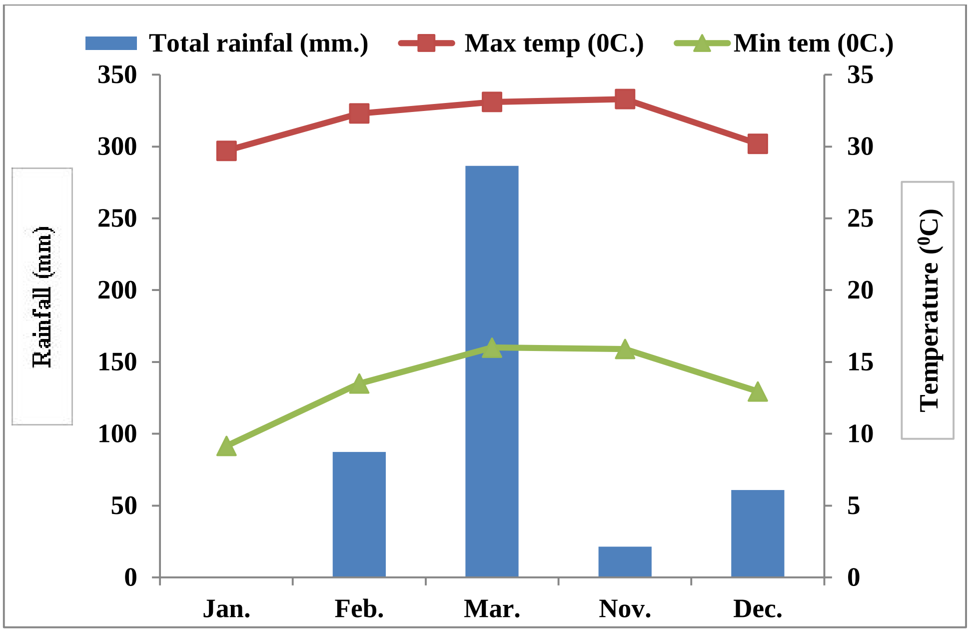

Fig. 1. Monthly total rainfall (mm), monthly meanmaximum and minimum temperature (^{0}C) during crop growing period (*Source: Metrological Department, Sylhet*)

Sweet potato (var. BARI Mishti Alu-12) as base crop, while BARI Red Amaranth-1, BARI Leaf Amaranth-1, mustard green (local cultivar) and local mustard cultivar were used as intercrops in this trial. The vine of sweet potato was planted at a spacing of 60 cm × 30 cm. The crops were fertilized with cow dung 5 t ha^{-1} and 129-34-130-12.8-4.3-1.4 kg ha^{-1} N-P-K-S-Zn-B in the form of urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, zinc sulphate and boric acid, respectively (Mondal *et al.*, 2014). Half of urea and all other fertilizers were used as basal during final land preparation. The vines of sweet potato and seeds of companion crops were planted or sown during 14-16 November in each year. Remaining N fertilizer was applied in side of the rows in two equal splits at 30 and 60 days after transplanting. Intercultural operations were done as and when required. There was no remarkable disease and pest attack. The companion crop was harvested on 15-20, December and sweet potato was harvested during 25-30 March in both the years. Mustard green and mustard were harvested as green vegetable. Data were taken from randomly selected 10 plants of sweet potato and yield data of all the crops were taken from whole plot. Collected data were pooled and means were adjusted by Least Significant Different (LSD) test at 5% level of significance. Agronomic performances, relative yield, sweet potato equivalent yield, land equivalent ratio of intercropping were calculated.

Relative yield (RY) of species was calculated (Harper, 1977) from the following formula:

$$RY = \frac{\text{Yield of a species of intercrop}}{\text{Yield of the same species in pure stand}}$$

Yield of individual crop was converted into sweet potato equivalent yield (SPEY) considering prevailing market price of the crops according to Islam *et al.*, (2014).

$$SPEY = \text{Yield of sweet potato in intercrop} + \frac{Yi \times Pi}{\text{Price of sweet potato}}$$

Where**,** Yi = yield of intercrops (vegetables) and Pi = Price of intercrop (vegetables).

Land equivalent ratio (LER) was calculated following the formula Mian (2008).

$$LER = RY_{SP} + RY_i = \frac{SP_{IY}}{SP_{SY}} + \frac{SP_{EYCC}}{SP_{SY}}$$

Where, RY_{sp}= Relative yield of sweet potato (main crop), RY_i= Relative yield of intercrops (vegetables), SP_{IY} = Yield of sweet potato in intercrop, SP_{SY} = Yield of sweet potato as sole crop, SP_{EYCC} = Sweet potato equivalent yield of component crops{(component crop yield in intercrop × price of component crop)/price of sweet potato}. Benefit cost analyses were also done.

Results and Discussion

Yield and yield contributing characters of sweet potato

Maximum vine length (80.70 cm) was recorded in T_5 (sole sweet potato). This longest vine length in T_5 than other treatment combinations might be due to no intercrop competition for light, nutrients, moisture and space. The results are in conformity with the findings of Islam (2014) and Das *et al.*, (2012). Among the intercropped, sweet potato + mustard combination (T_4) produced the highest vine length (74.90 cm) but this was not similar to that of T_1 and T_3. T_2 (sweet potato + leaf amaranth) produced the lowest vine length (Table 1). Broad leaves of mustard and mustard green might help to keep soil moisture for better soil microclimate and growth of plants. The result was consistent with the findings of Kumar *et al.*, (2010) intercrops should have either synergistic or complementary effect relative to the base crops. Maximum number of roots plant^{-1}(3.93) was obtained from T_5 (sweet potato sole) which was identical to that of T_4 (sweet potato + mustard). It was observed that number roots plant^{-1} was not influenced by any combination of intercrop (Table 1). The average weight of single root tubers was also varied with the variation of intercrop combinations. The highest weight (168.53 g) of single root tuber was found in sole sweet potato followed by sweet potato + mustard (161.57 g).

The lowest weight of single root was recorded from sweet potato + leaf amaranth combination and it was not different from sweet potato + red amaranth and sweet potato + mustard green combination (Table 1). The effect of intercropping of sweet potato with red amaranth, leaf amaranth, mustard green and mustard provided yields of tuberous root were non-significant (Table 1). Among the intercropped combinations numerically the maximum tuberous root yield (30.53 t ha^{-1}) was recorded when 100% sweet potato intercropped with 100% mustard greenthat was very close to that of sweet potato intercropped with mustard. This higher tuberous root yield of sweet potato might be due to synergetic complementary effect of broad leaves green mustard to the base crop. Generally, the tuberous root yields of sweet potato under intercropping treatments were lower than that of sweet potato sole. The reduction of sweet potato yield was possibly due to intercrop completion between two crops. However, additional yield from mustard/leafy vegetable gave extra income.

Relative yield of sweet potato

Relative yield determines competitive ability of component crops in intercropping system. Greater value of relative yield showed more competitive ability in intercrop situation compared to its monoculture (Juskiw *et al.*, 2000). The relative yields of sweet potato were 0.95, 0.96, 0.99 and 0.97 when sweet potato was intercropped with red amaranth, leaf amaranth, mustard green and mustard, respectively (Table 1). This indicates that sweet potato yield was reduced by 5, 4, 1and 3% of sole crop when it was intercropped with red amaranth, leaf amaranth, mustard green and mustard, respectively. The lower relative yield of sweet potato in intercropping indicated that the crop faced competition for space, nutrients, light, and water with component crops. The results are in agreement with the findings of Baghdadi *et al*., (2016) and Rahman (1999).

Table 1. Length of vine, roots $plant^{-1}$, weight of single root and yield of root tuber of sweet potato base intercropping system (pooled data of two years).

Treatments	Length of vine (cm)	Tuberous roots $plant^{-1}$	Weight of single root tuber (g)	Root yield (t ha^{-1})	Relative yield of sweet potato
T_1:Sweet Potato+ red amaranth	70.83	3.13	149.30	29.17	0.95
T_2:Sweet Potato+ leaf amaranth	62.97	3.10	145.83	29.50	0.96
T_3:Sweet Potato+ mustard green	74.27	3.30	154.77	30.53	0.99
T_4:Sweet Potato+ mustard	74.90	3.47	161.57	29.77	0.97
T_5:Sweet potato as sole crop	80.70	3.93	168.53	30.60	1.00
CV (%)	5.98	8.13	4.59	4.60	-
$LSD_{(0.05)}$	8.19	0.52	13.47	NS	-

NS= Not significant.

Companion crops yield

On an average, the yields of red amaranth, leaf amaranth, mustard green and mustard as vegetable under intercrops were 4.40, 5.43, 5.60 and 4.50 t ha^{-1}, respectively. Among them mustard green produced higher yield (5.60 t ha^{-1}) by T_3 and lower yield (4.40t ha^{-1}) was produced by T_1 (Table 2).

Sweet potato equivalent yield (SPEY)

The equivalent yield is expressed in total productivity of a system. Sweet potato equivalent yields were higher in all the intercrop combination (31.52 - 41.75 t ha^{-1}) than the sweet potato sole (30.60 t ha^{-1}). The maximum sweet potato equivalent yield (41.75 t ha^{-1}) was recorded in T_3 (sweet potato + mustard green) which was followed by T_4 (sweet potato + mustard), T_2 (sweet potato+ leaf amaranth) and T_1 (sweet potato+ red amaranth) combinations. On the contrary, minimum SPEY was obtained from T_5 (sweet potato as sole). The results indicate the SPEY vary mainly due to variation in yields of component crops *i. e.* combined yield of sweet potato and component crops. Contrastingly, the total productivity also increases of 14.36, 36.37, 10.59 and 3.00 % in sweet potato + mustard, sweet potato + mustard green, sweet potato + leaf amaranth and sweet potato + red amaranth combinations over sole sweet potato (Table 2) cultivation practice. This result showed that T_3 (sweet potato+ mustard green) lead to higher total productivity than sole sweet potato. The results are agreement with the findings of Ahmed *et al.*, (2013) and Khan *et al.*, (2017).

Land equivalent ratio (LER)

Land equivalent ratio was calculated to determine land use efficiency in the intercrop systems. Highest land equivalent ratio (1.37) was recorded in T_3 (sweet potato+ mustard green) intercropping system followed by T_4 (sweet potato + mustard). The lowest LER (1.03) was in T_1 (sweet potato + red amaranth) combination. LER of different crop combinations ranged from 1.03 to 1.37 indicating 103-137 % land utilize by intercropping. Total LER of all intercropping treatments was more than one, which shows an advantage over pure stands in terms of the use of environmental resources for plant growth as reported by Beyenesh *et al.,* (2017). The mean values of LER (more than one) in all intercropping treatments revealed that land was more efficiently utilized under intercropping than sole cropping of sweet potato. It also expresses that by intercropping of sweet potato with mustard green, a farmer can produce 30.53 t ha^{-1} tuberous roots of sweet potato and 5.60 t ha^{-1} yield of mustard green from one hectare of land instead of growing sweet potato sole cultivation.

Table 2. Yield of companion crops, sweet potato equivalent yield (SPEY) and land equivalent ratio (LER) under sweet potato base intercropping system (pooled data of two years).

Treatments	Yield of companion crops (t ha^{-1})	SPEY (t ha^{-1})	% increase of SPEY over sole sweet potato	LER
T_1:Sweet Potato+ red amaranth	4.40	31.52	3.00	1.03
T_2:Sweet Potato+ leaf amaranth	5.43	33.84	10.59	1.10
T_3:Sweet Potato+ mustard green	5.60	41.75	36.37	1.37
T_4:Sweet Potato+ mustard	4.50	35.17	14.93	1.15
T_5:Sweet potato as sole crop	-	30.60	-	1.00

Cost benefit analysis

Intercrop combination of sweet potato with short durated leafy vegetables showed higher monetary return over sole crop (Table 3). The highest gross return (Tk. 625950 ha^{-1}) was recorded from T_3 (sweet potato + mustard green) intercrop combination which was 36.37 % higher than sole cultivation of sweet potato. This intercropping combination also gave the higher gross margin (Tk. 495500 ha^{-1}) and benefit cost ratio (4.80) followed by T_4 (sweet potato + mustard) combination. The lowest gross return (Tk. 459000 ha^{-1}), gross margin (Tk. 330300 ha^{-1}) and BCR (3.57) were obtained from sole cultivation of sweet potato.

Table 3. Cost benefits analysis of sweet potato base vegetables intercropping system (average data of two years).

Treatments	Gross return (Tk. ha^{-1})	Cost of production (TK. ha^{-1})	Gross margin (TK. ha^{-1})	Benefit cost ratio (BCR)
T_1:Sweet Potato+ red amaranth	472800	131500	341300	3.60
T_2:Sweet Potato+ leaf amaranth	507600	131200	376400	3.87
T_3:Sweet Potato+ mustard green	625950	130450	495500	4.80
T_4:Sweet Potato+ mustard	527550	129580	397970	4.07
T_5:Sweet potato as sole crop	459000	128700	330300	3.57

Price (Tk. Kg^{-1}): Sweet potato: 15.00, Red amaranth: 8.00, Leaf amaranth: 12, Mustard green: 30.00, Mustard: 18.00

Conclusion

It appears from the results that total productivity along with crop diversification can be possible through intercropping system. However, sweet potato 100% + mustard green (Lai shak) 100% combination could be suggested to grow in Sylhet region under AEZ 20 for higher productivity and economic return.

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