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Performance of T. *aman* rice-cum-vegetables as influenced by selected species of trellis-grown vegetables and nature of trellis

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Abstract: The experiment was carried out during the period from July 2005 to December 2005 with a view to observing the relative performance of flat trellis and T-trellis (180 cm breadth) in response to the T. *Aman* rice cv. BRRI dhan41 and selected trellis-grown vegetable. The treatments comprised four crop combinations viz. rice + bottle gourd (C_1), rice + white gourd (C_2), rice + bitter gourd (C_3) and rice + yard long bean (C_4), and four types of nature of trellises viz. Flat trellis (control) (T_1), Slant T-trellis (Fixed) (T_2), Flat T-trellis (T_3) and Slant T-trellis (Flexible) (T_4). The experiment was laid out in a randomized complete block design with three replications. T. *Aman* rice cv. BRRIdhan41 was fertilized with 220, 50, 60, 35 and 5 kg ha^{-1} of urea, triple superphosphate, muriate of potash, gypsum and zinc sulphate, respectively. Thirty-day old rice seedlings were transplanted on 04 August 2005. The 50 cm breadth and raised *ail*s were prepared and fertilized with different kinds of fertilizers and manures according to dike cropping manual. Vegetable seedlings were planted on 14 August 2005.Trellises (180 cm breadth) were made in the middle of the plot to minimize the shading effect on rice crop. After sampling the whole plot was harvested at maturity on 16 December 2005. Rice equivalent yield, gross return, net return and benefit-cost ratio were also calculated. The experimental results revealed that the lowest grain yield (4.29 t ha^{-1}) of rice was obtained from the crop combination of rice + yard long bean (C_4) with yield reduction of only 4.7% as compared to the highest grain yield of 4.50 t ha^{-1}. Regarding vegetable yield, bottle gourd (C_1) on the *ail*s of rice plots gave the highest yield of 13.63 t ha^{-1} followed by 9.01 t ha^{-1} in white gourd (C_2). Bitter gourd (C_3) and yard long bean (C_4) were almost damaged by heavy and continuous rainfall during the growing period. Except flat trellis (T_1), there were no remarkable differences among the nature of trellis treatments. Flat T-trellis (T_3) appeared as the best (4.58 t ha^{-1}). Flat trellis (T_1) gave the lowest grain yield (4.20 t ha^{-1}) of rice with yield reduction of only 8.0% as compared with flat T-trellis (T_3). There was compensation in vegetable yield with respect to nature of trellis. Regarding vegetable production, flat T-trellis (T_3) produced the highest vegetable yield (7.45 t ha^{-1}) followed by flat trellis (T_1) (6.47 t ha^{-1}). As a result, these two types of trellises were found equally good in terms of producing higher rice equivalent yields. In vegetable cultivation with T. *Aman* rice crop, the highest values of gross return (Tk. 191,820 ha^{-1}), net return (Tk. 133,890 ha^{-1}) and benefit-cost ratio (3.31) were obtained from C_1T_3 (rice + bottle gourd and 180 cm breadth flat T-trellis) treatment (Table 3). The lowest values of gross return (Tk. 93,190 ha^{-1}), net return (Tk. 36,690 ha^{-1}) and benefit-cost ratio (1.65) were recorded from C_2T_4 (rice + white gourd and flexible slant T-trellis) treatment combination.
Key words: Performance, trellis, vegetable and T. a*man* rice.

Introduction

Rice is grown in the *Aus*, *Aman* and *Boro* seasons in Bangladesh. It occupies about 76% of the total cropped area. Rice holds the area of 10.78 million hectares with a production of 25.19 million tons of grain. On the other hand, any sustainable vegetable production system in Bangladesh is lacking. Vegetable crops excluding potato occupy only 1.8% of the total cropped area with a gross production of only 1.63m tons (BBS, 2004). But the per capita consumption of vegetable in Bangladesh is only 53g, which is far behind the daily human requirement of 200g/head/day. Our vegetable requirement is 10.22mtons/year against the current production of 2.71mtons/year (Rashid, 1999).

Increasing the total land area for vegetable production in Bangladesh seems to have little scope, because of decreasing trend in the land-man ratio. In Bangladesh, the arable land is decreasing by approximately 1.0% of the total area per annum in view of the alarming population growth rate, rapid industrialization and urbanization, and hence, the demand for food grain is ever increasing (Anonymous, 2006). In context of the growing demand for food, an additional need to raise crop production per unit area is being felt seriously. Therefore, the only avenue left is to increase the production of crops through intensive care, management and adoption of new dimension of technologies.

Now, in order to increase and stabilize agricultural production the means that has greatly received the attention of scientists in the recent years is multiple cropping or intercropping. In this form of production practice, more than one crop is grown simultaneously or in sequence on the same piece of land (Harwood, 1973). Very recently vegetable production in the rice fields, a new concept of multiple cropping, has been under proposition in conditions of Bangladesh, which might produce high potentiality in terms of total production and economic return. In this condition, there is a strong demand that vegetable production is to be increased, although the horizontal expansion of land for vegetable cultivation is not possible. In these scenarios, this problem may be addressed by producing high yielding vegetable crops simultaneously on the *ail*s of rice fields as mixed crops.

In *Boro* season, the climate remains suitable for cultivation of several vegetable crops in Bangladesh. On the other hand, unavailability of high land in the wet season is the main constraint to vegetable production during the period from June to October. So, the *ail*s of the rice fields (*Ail*s means the border of rice plots that is used mainly for control of water movement is popularly known as *ail*s all over Bangladesh) is the only left avenue and this land area is our main concern. So, we should try to explore that land for vegetable cultivation along with rice crop. Thus in these circumstances, in addition to using the conventional methods of vegetable production, non-conventional means such as, growing several vegetable crops on the *ail*s of rice crop may be explored. Therefore, the present research work was undertaken to find out the performance of T. *Aman* rice-cum-vegetables as influenced by selected species of trellis-grown vegetables and nature of trellis.

Materials and Methods

The experiment was carried out at the Agronomy Field Laboratory, Mymensingh, Bangladesh during the period from July 2005 to December 2005 with a view to observing the relative performance of flat trellis and T-trellis (180 cm breadth) in response to the T. *Aman* rice cv. BRRI dhan41 and selected trellis-grown vegetable. The treatments comprised four crop combinations viz. rice + bottle gourd (C_1), rice + white gourd (C_2), rice + bitter gourd (C_3) and rice + yard long bean (C_4), and four types of nature of trellises viz. Flat trellis (control) (T_1), Slant T-trellis (Fixed) (T_2), Flat T-trellis (T_3) and Slant T-trellis (Flexible) (T_4). The experiment was carried out in a randomized complete block design with three replications and the unit plot was 4.0m × 2.5m. Rice crop was fertilized with 220, 50, 60, 35 and 5 kg ha^{-1} of urea, triple superphosphate, muriate of potash, gypsum and zinc sulphate, respectively (BRRI, 2004). The whole amount of fertilizers except urea was given during final land preparation as basal application. Urea fertilizer was top dressed at 20 and 55 DAT of rice. Thirty-day old rice seedlings were transplanted on 04 August 2005. The 50 cm breadth and raised *ail*s were prepared and fertilized with different kinds of fertilizers and manures according to dike cropping manual (Alam, 2000). All the vegetable crops were transplanted on the *ail*s of rice plot maintaining a distance of 50 cm from pit to pit and later on these were given on to the trellis made of bamboo and plastic rope arrangements On the other hand, Vegetable seedlings were planted on 14 August 2005.Trellises (180 cm breadth) were made in the middle of the plot to minimize the shading effect on rice crop. Intercultural operations were done and plant protection measures were taken as per requirement of the rice-cum-vegetable cultivation. Five rice hills were selected randomly from each plot and uprooted before harvesting for recording data other than yields. After sampling the whole plot was harvested at maturity on 16 December 2005. Here, vegetable yield assessment was made not on the basis of area on which vegetables were grown but on the basis of whole plot. Rice equivalent yield, gross return, net return and benefit-cost ratio were also calculated. Data were analyzed and the mean differences were adjudged among the treatments by Duncan's Multiple New Range Test (Gomez and Gomez, 1984).

Results and Discussion

Effect of vegetable crop combination: Results showed that crop combination exerted significant influence on number of total tillers $hill^{-1}$, number of grains and total spikelets $panicle^{-1}$, grain and straw yields of rice along with vegetable and rice equivalent yields while other characters were not significantly affected (Table 1). Number of total tillers $hill^{-1}$ was significantly affected by the crop combination. The result showed that the maximum number of total tillers $hill^{-1}$ (13.68) was produced in rice + bitter gourd (C_3) crop combination and the minimum number of total tillers $hill^{-1}$ (12.83) was produced in rice + white gourd (C_2),which was statistically identical to C_1 (13.18) and C_4 (13.13) crop combinations. Number of total spikelets $panicle^{-1}$ of rice was statistically different as influenced by different crop combinations. The highest number of total spikelets $panicle^{-1}$ (190.9) was obtained from rice + bottle gourd (C_1), which was statistically identical to C_3 (190.2) and C_4 (186.0) crop combinations while the lowest number of total spikelets $panicle^{-1}$ (179.0) was recorded from rice + white gourd (C_2) crop combination (Table 1). Among crop combinations, the differences between treatments were not much remarkable. Grain yield reductions due to trellis-grown vegetables were just marginal. The lowest grain yield (4.29 t ha^{-1}) of rice was obtained from the crop combination of rice + yard long bean (C_4) with grain yield reduction of only 4.7% as compared to the highest grain yield of 4.50 t ha^{-1} (Table 1).

Table 1. Yield and yield attributes of T. Aman rice cv. BRRI dhan41 and vegetable yield as influenced by the crop combination in the rice cum vegetable cultivation system

Crop combination	Plant height (cm)	No. of effective tillers $hill^{-1}$	No. of total tillers $hill^{-1}$	Panicle length (cm)	No. of total spikelets $panicle^{-1}$	Grain yield (tha^{-1})	Straw yield (tha^{-1})	Vegetable yield (tha^{-1})	Rice equivalent yield (tha^{-1})	SAR (%)
C_1 (R + Bo)	131.7	8.75	13.18b	27.18	190.9a	4.50a	5.12	13.63a	16.61a	13.0
C_2 (R + W)	133.1	8.82	12.83b	26.13	179.5b	4.33b	4.95	9.01b	12.34b	9.0
C_3 (R + Bi)	134.6	9.07	13.68a	26.65	190.2a	4.36ab	4.99	-	4.36c	13.0
C_4 (R + Y)	131.7	8.97	13.13b	26.55	186.0ab	4.29b	4.92	-	4.29c	7.0
Level of sig.	NS	NS	0.01	NS	0.05	0.05	NS	0.01	0.01	
CV (%)	4.52	7.58	3.17	4.54	5.26	3.99	7.51	11.38	6.51	

In a column, the treatment means having similar letter(s) do not differ significantly, 'NS' means not significant, C_1: Rice + Bottle gourd (Bo), C_2: Rice + White gourd (W), C_3: Rice + Bitter gourd (Bi), C_4: Rice + Yard long bean (Y); SAR = Solar Radiation Rduction

Results showed that crop combination showed significant effect on vegetable yield (Table 1). In vegetable production with T. *Aman* rice, bottle gourd (C_1) gave the highest yield of 13.63 t ha^{-1} on the *ail*s of rice plots followed by 9.01 tha^{-1} in white gourd (C_2). On the other hand, bitter gourd (C_3) and yard long bean (C_4) were almost damaged by heavy and continuous rainfall. Results showed that crop combination exhibited significant influence on rice equivalent yield (Table 1). It was observed that the highest rice equivalent yield (16.61 t ha^{-1}) was obtained with bottle gourd (C_1) followed by 12.34 t ha^{-1} in white gourd (C_2) and the lowest value (4.29 t ha^{-1}) received from rice + yard long bean (C_4), which was identical to rice + bitter gourd (C_3). It appeared that higher rice equivalent yields with trellis-grown vegetable of bottle gourd (C_1) and white gourd (C_2) are highly profitable. This result also corroborates with the findings of Saha (2002).

In vegetable cultivation along with T. *Aman* rice, the variation in intensity of light differed significantly due to different crop combinations (Table 1). Results indicated that there was no wider variation in intensity of light that were received from different crop combinations. Results also showed that reduction in interception of solar radiation ranging from 7.0% to 13.0% was observed among the treatments compared to control treatment (C_0).

Table 2. Yield and yield attributes of T. *Aman* rice cv. BRRI dhan41 and vegetable yield as influenced by the nature of trellis in the rice cum vegetable cultivation system

Nature of trellis	Plant height (cm)	No. of effective tillers hill^{-1}	No. of total tillers hill^{-1}	Panicle length (cm)	No. of total spikelets panicle^{-1}	Grain yield (tha^{-1})	Straw yield (tha^{-1})	Vegetable yield (tha^{-1})	Rice equivalent yield (tha^{-1})
T_1	130.0	8.62	12.65b	26.50	183.3	4.20c	4.75b	6.47b	9.95b
T_2	132.7	9.02	13.45a	26.88	188.4	4.41b	5.06ab	4.59c	8.49c
T_3	136.7	9.23	13.78a	26.32	191.1	4.58a	5.28a	7.45a	11.20a
T_4	131.8	8.73	12.95b	26.80	183.8	4.30bc	4.89b	4.13c	7.97d
Level of sig.	NS	NS	0.01	NS	NS	0.01	0.01	0.01	0.01
CV (%)	4.52	7.58	3.17	4.54	5.26	3.99	7.51	11.38	6.51

In a column, the treatment means having similar letter(s) do not differ significantly; 'NS' means not significant; Note: T_1: Flat trellis (Control), T_2: Slant T-trellis (Fixed), T_3: Flat T-trellis, T_4: Slant T-trellis (Flexible)

Table 3. Cost and return of vegetable cultivation along with T. *Aman* rice cv. BRRI dhan41

Treatment combination	Total cost of production (Tk. ha^{-1})	Return (Tk. ha^{-1})		Gross return (Tk. ha^{-1}) (a + b)	Net return (Tk. ha^{-1})	Benefit-cost ratio
		From main product (a)	From by-product (b)			
C_1 (R + Bo) X T_1	57,930	158,310	4,880	163,190	105,260	2.82
T_2	57,930	131,220	5,090	136,310	78,380	2.35
T_3	57,930	186,300	5,520	191,820	133,890	3.31
T_4	57,930	122,220	4,990	127,210	69,280	2.20
C_2 (R + W) X T_1	56,500	126,180	4,820	131,000	74,500	2.32
T_2	56,500	94,410	4,970	99,380	42,880	1.76
T_3	56,500	135,270	5,110	140,380	83,880	2.48
T_4	56,500	88,290	4,900	93,190	36,690	1.65
C_3 (R + S) X T_1	54,428	36,900	4,650	41,550	-12,878	0.76
T_2	54,428	40,950	5,200	46,150	-8,278	0.85
T_3	54,428	41,310	5,290	46,600	-7,828	0.86
T_4	54,428	37,980	4,820	42,800	-11,628	0.79
C_4 (R + Bi) X T_1	49,483	36,720	4,630	41,350	-8,133	0.84
T_2	49,483	38,880	4,970	43,850	-5,633	0.89
T_3	49,483	40,410	5,190	45,600	-3,883	0.92
T_4	49,483	38,430	4,870	43,300	-6,183	0.88

Note: T_1: Flat trellis (Control), T_2: Slant T-trellis (Fixed), T_3: Flat T-trellis, T_4: Slant T-trellis (Flexible) ; C_1: Rice + Bottle gourd, C_2: Rice + White gourd, C_3: Rice + Bitter gourd, C_4: Rice + Yard long bean, Bottle gourd = Tk. 8.00 kg^{-1}, White gourd = Tk. 8.00 kg^{-1}, Bitter gourd = Tk. 14.00 kg^{-1} , Yard long bean = Tk. 12.00 kg^{-1}, Rice grain = Tk. 9.00kg^{-1}, Rice straw = Tk. 1.00

Effect of nature of trellis: It was found that nature of trellis showed significant influence on number of total tillers hill^{-1} and number of grains panicle^{-1}, grain and straw yields together with vegetable and rice equivalent yields while other characters remained unaffected (Table 2). Results presented in the Table 2 showed that the highest number of total tillers hill^{-1} (13.78) were produced from T_3 treatment, which was similar to T_2 treatment. The lowest number of total tillers hill^{-1} (12.65) was recorded from T_1 treatment that was identical to T_4 treatment. Variation in number of grains panicle^{-1} was significant. It was observed that flat T-trellis (T_3) gave the highest number of grains panicle^{-1} (176.1), which was similar to T_2 treatment. The lower number of grains panicle^{-1} (162.4) was recorded from flat trellis (T_1), which was identical to T_4 treatment. Except flat trellis (T_1), there were no remarkable differences among the nature of trellis treatments. Flat T-trellis (T_3) appeared as the best (4.58 t ha^{-1}). Flat trellis (T_1) gave the lowest grain yield (4.20 t ha^{-1}) of rice with yield reduction of only 8.0% as compared with flat T-trellis (T_3) (Table 2). Here, T-trellis with 180 cm breadth (T_3) showed better performance in respect of rice yield than that of flat trellis (T_1) treatment. The probable reason might be that flat T-trellis (T_3) gave little shade on rice plot because it was made in the middle of the *ail*s of rice plots as well as vegetable area coverage on rice plot was minimum than that of flat trellis (T_1) treatment. There was significant difference in the straw yield due to nature of trellis. The T_3 treatment produced the highest straw yield (5.28 t ha^{-1}), which was similar to T_2 treatment. The lowest straw yield (4.75 t ha^{-1}) was obtained from flat trellis (T_1) treatment, which was statistically identical to T_4 (4.89 t ha^{-1}) treatment. The highest straw yield was attributed due to higher number of total tillers $hill^{-1}$.

Nature of trellis showed significant influence on vegetable yield (Table 2). In terms of vegetable yield, flat T-trellis (T_3) produced the highest vegetable yield (7.45 t ha^{-1}) followed by flat trellis (T_1) (6.47 t ha^{-1}) and the lowest vegetable yield (4.13 t ha^{-1}) produced from slant T-trellis (Flexible) (T_4) treatment.

There was significant difference among the nature of trellis treatments on rice equivalent yield (Table 2). Flat T-trellis (T_3) gave the highest v rice equivalent yield (11.20 t ha^{-1}) followed by flat trellis (T_1) (9.95 t ha^{-1}). As a result, these two types of trellises were found good in terms of producing higher rice equivalent yields. Slant T-trellis (Fixed) (T_2) and slant T-trellis (Flexible) (T_4) were found inferior in terms of producing rice equivalent yields.

Cost Analysis: In vegetable cultivation with T. *Aman* rice crop, the highest values of gross return (Tk. 191,820 ha^{-1}), net return (Tk. 133,890 ha^{-1}) and benefit-cost ratio (3.31) were obtained from C_1T_3 (rice + bottle gourd and 180 cm breadth flat T-trellis) treatment (Table 3). The lowest values of gross return (Tk. 93,190 ha^{-1}), net return (Tk. 36,690 ha^{-1}) and benefit-cost ratio (1.65) were recorded from C_2T_4 (rice + white gourd and flexible slant T-trellis) treatment combination. This result indicated that in most cases sole rice cultivation is less remunerative than the plot provided with vegetables.

From the above study it could be concluded that bottle gourd and white gourd vegetable cultivation along with T. *Aman* rice crop is remunerative in terms of both yield and economics. While rice cultivation alone, because of its high input cost, is comparatively less profitable. So, rice cultivation could be made profitable by simultaneously growing vegetable on the *ail*s of rice plots. Therefore, both flat trellis (T_1) and flat T-trellis with 180 cm breadth (T_3) were effective kind of trellis for this type of vegetable and rice production as because, these types of trellises provide minimum shading effects on the growing crops underneath.

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