Journal BiNET
Scientific Publication

Published with Open Access at Journal BiNET
Vol. 14, Issue 02: 1202-1209

Journal of Bioscience and Agriculture Research

Journal Home: www.journalbinet.com/jbar-journal.html

Multiple cropping for sustainable and exaggerated agricultural production system

M. Sazzad Hossain[1], Md. Abdul Kader[2] and Najrul Islam[2]

[1]Dept. of Agronomy and Haor Agriculture, Sylhet Agricultural University, Sylhet 3100
[2] Dept. of Agronomy, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh

✉ For any information: ask.author@journalbinet.com, Available online: 14 August 2017.

ABSTRACT

Multiple cropping is a farming practice involving two or more crop species or genotypes growing together and coexisting for a certain period. It is getting importance as farmers intensifying land use to remain competitive and provide the increasing world demand for different crop originated products and in many subsistence or low-input/resource-limited agricultural systems on the fringes of modern intensive agriculture. By providing actual yield gains without increased inputs, or greater stability of yield with decreased inputs, multiple cropping becomes one unique route to delivering sustainable intensification. Innovations by agricultural scientists in pesticides, no-till instrumentation, rotation of legumes and grasses for tap-rooted and fibrous -rooted crops, and breeding crops tailored to specific systems and environments create intensified multiple cropping farming more successful. With this connection, the experiment was carried out to study effect of intercropping combinations (rice with four different vegetables) on land use efficiency using the Land Equivalent Ratio (LER) and total return per unit area based on benefit-cost ratio (BCR). Intercropping combinations had significant effect on LER and BCR for total return. Result showed that the lowest cost of production was found in sole rice under monoculture compared to all other cases of polyculture. But sole rice cultivation under monoculture is less profitable than the production of vegetable-rice intercropping. Vegetable cultivation along with rice crop is remunerative in both yield and economical point of view.

Key Words: *Benefit-cost ratio, Land equivalent ratio, Multiple cropping, Rice, Vegetabl and Yield.*

Cite Article: Hossain, M. S., Kader, M. A. and Islam, N. (2017). Multiple cropping for sustainable and exaggerated agricultural production system. Journal of Bioscience and Agriculture Research, 14(02), 1202-1209. **Crossref:** https://doi.org/10.18801/jbar.140217.148

I. Introduction

There are many techniques to enrich food production such as expanding arable land, increasing cropping intensity, improvement in technology, research, and extension of information to producers to improve genetics of crops, improve soil quality, eliminate or manage pests for improved yields of traditional crops (Anon, 1990). The area of world's cultivated land expanded by only 4% whiles the world's population increased by 40%world population growth. So, expanding cultivated arable land is not a viable solution for producing a sustainable world food supply. Improved technology and other facilities are cost intensive. Tying all the above-mentioned techniques together revealed a promising alternative way which is multiple cropping. 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 (Zhang et al., 2010; Li et al., 2013). In this form of production practice, more than one crop is grown simultaneously or in sequence on the same piece of land (Harwood and Hiquita, 1976). There are several types of multiple cropping where two or more crops are grown in succession on the same land per year. These forms are generally known as sequential cropping (which includes double cropping, triple cropping, quadruple cropping, quintuple, sextuple, septuple etc.), intercropping (which includes strip and row intercropping) (Ghaffarzadeh et al., 1994; West and Griffith, 1992), Mixed cropping, Relay cropping. In this case second crop is sown while the first crop is near maturity. This is the most convenient and effective way of sustainable agricultural production, where growing more than one food, feed, fiber, industrial, green manure, mulch, or rotation crop on the same land area at the same period is possible (Li et al., 2009). This technique makes effective use of inputs such as soil, water, fertilizer etc. resulting increased per unit area with manifold returns to the growers. In multiple cropping system justified fertilizer recommendation and inputs use is crucial for sustainability (Sultana et al., 2015; Hossain and Siddique, 2015). Multiple cropping can be done by annual food crops, fodders, vegetables, fruit plants and perennial crops. It could enable the country to be self-sufficient in food production and export the surplus to earn foreign currency. Proper maintenance of soil fertility, minimum incidence of crop failure owing to natural calamities and biotic agents, efficient utilization of nutrients and land, diverse foods outputs and enhanced food production are ultimate achievements of multiple cropping (Iannetta et al., 2013; Powlson et al., 2011; Johnson et al., 2009; Adu-Gyamfi et al., 2007). Multiple cropping increases the potential for total production and farm profitability than monocropping (Anon, 1990; Martin et al., 1987). The uptake and mobilization of micronutrients is also influenced by intercropping, especially Fe in peanut and maize intercropping systems (Zheng et al., 2003; Zuo et al., 2003).

The increase in productivity per unit of land is one of the most important reasons of multiple cropping (Inal et al., 2007). For assessing intercrop performance as compared to pure stand yields a method is designed. By growing mixtures and pure stands in separate plots the yields are measured and also an assessment of the land requirements per unit of yield can be determined. By this information the yield advantage of the intercrop over the pure stand and how much additional land is required in pure stand to equal the amount of yield achieved in the intercrop become clear (Kurata, 1986; Pathick and Malla, 1979). The calculated figure is called the Land Equivalency Ratio (LER). The LER is calculated using the formula LER= Σ (Ypi/Ymi), where Yp is the yield of each crop or variety in the intercrop or polyculture, and Ym is the yield of each crop or variety in the sole crop or monoculture. LER measures 1.0 means the amount of land required for W and Y grown together is the same as that for W and Y grown in pure stand (i.e. there was no advantage to intercropping over pure stands). LERs above 1.0 show an advantage to intercropping while numbers below 1.0 show a disadvantage to intercropping. For example, an LER of 1.25 tells us that the yield produced in the total intercrop would have required 25% more land if planted in pure stands. If the LER was 0.75 then we know the intercrop yield was only 75% of that of the same amount of land that grew pure stands (Agrawal, 1995; Francis and Decoteau, 1993; Kurata, 1986; Mazaheri and Oveysi, 2004; Laster and Furr, 1972). The Benefit-Cost Ratio (BCR) is a profitability index, used in the formal discipline of cost-benefit analysis (Quigley et al., 2003. A French Engineer Jules Dupuit (1848) first introduced the concept of benefit cost ratio which was further enhanced by British economist Alfred Marshall and became the basis for benefit cost ratio (Marshall and Brown, 1974). In course of time, the agricultural land is being reduced by approximately 1.0% of the total area per annum (Hussain et al., 2006) while the population is increasing by 1.24% (ERB, 2007), and hence, the demand for food grain is ever increasing. Inadequate information and research are the main reasons for low adoption of multiple cropping. With this view, the economic benefits of multiple cropping, there is a need to promote it among the farming community. The aim of the research on rice cum vegetable intercropping is to assess the suitability and profitability of multiple cropping best fitted to the resource poor farmer of Bangladesh.

II. Materials and Methods

The experiment was carried out at the Agronomy research farm of Bangladesh Agricultural University during the year 2008. The main intercropping crop species are rice (*Oryza sativa*) variety Surjamoni combined with four different types of vegetable crops like yard long bean (*Vigna unguiculata*), snake gourd (*Trichosanthes anguina*), white gourd (*Benincasa hispida*) and bottle gourd (*Lagenaria vulgaris*) were used as plant materials. Rice seedlings were raised in seedbed and transplanted to the main field following standard line sowing method. Seedlings of vegetables were raised in polybag and in seedbed which was prepared on the levee in between two trellises. The media was prepared mixing organic manure and compost with field soil. Healthy seeds of yard long bean, snake gourd, white gourd and bottle gourd were sown in the prepared media in polybag. The polybags were kept in a sunny and dry place. Proper water and pest management practices were done to raise good seedlings. Thirty-day-old seedlings of snake gourd, white gourd and bottle gourd and fifteen-day-old seedlings of yard long bean were transplanted. The seedlings of these vegetables were planted on the levee of rice plots and allowed to grow on trellis (bamboo made scaffold and branches of jujube) during the whole growth period, afterwards. Five different types of crop combinations, T0 = Rice only, T_1 = Yard long + rice, T_2 = Snake gourd + rice, T_3 = White gourd + rice and T_4 = Bottle gourd + rice were used as treatments. The experiment was laid out in a randomized complete block design (RCBD) having three replications. There were 49 unit plots of same size (3 x 6 m^2) where Plot to plot and block to block distances were 75 cm and 100 cm, respectively. The experimental plots were fertilized with 270, 150, 120, 110 and 15 kg ha^{-1} of urea, triple superphosphate, muriate of potash, gypsum and zinc sulphate, respectively. The amount of fertilizers for four types of plot was calculated and the entire amount of triple superphosphate, muriate of potash, gypsum and zinc sulphate was applied during final land preparation as basal application. One-third of urea was top dressed at 15 days after transplanting (DAT) and the rest of urea was top dressed in two equal splits at 45 and 55 DAT. For vegetables, fertilization of the levee soil was done with cowdung, urea, triple superphosphate and muriate of potash @ 10 kg, l00 g, 120 g and l00 g, respectively. Cowdung, TSP and MP were mixed with soil at the time of ail preparation. Urea was applied in ring form at a certain distance from the base of the vegetables seedlings about 15 DAT. The plots were hand weeded in different vegetative stages. Each plot was harvested individually to estimate grain and biological yield. Total cost and returns were calculated to find out the benefit-cost ratio (BCR) and Land Equivalency Ratio (LER). Data were statistically analyzed using analysis of variance technique appropriate for randomize complete block design with plant densities split on planting dates and Duncan's Multiple Range Test (Gomez and Gomez, 1984). ($p<0.05$) was employed for mean separation when F-values were significant. In case of vegetables, yield data was collected then converted to rice equivalent yield and finally subjected for economic analysis.

III. Results and Discussion

Rice yield

In rice cum vegetable cultivation, crop combination exerted significant influence on the different yield and yield attributes of rice. The highest grain yield (6.9 t ha^{-1}), straw yield (9.70 t ha^{-1}), biological yield (16.60 t ha^{-1}) and harvest index (41.87%) were observed under sole rice crop (Figure 01 and 02). The lowest grain yield (5.16 t ha^{-1}), straw yield (8.16 t ha^{-1}) and biological yield (13.31 t ha^{-1}) were observed under the treatment of bottle gourd + rice (Figure 01). In biomass production in species-diverse systems was, on average, 1.7 times higher than in monoculture (Cardinale *et al*., 2007).

Vegetable yield

Four types of vegetable were cultivated with rice (cv. Surjamoni) on the levee along with bamboo made scaffold and branches of jujube. All the vegetables included in the experiment were climbing type. The vegetable crops under study did perform well in combination of rice but different yield was obtained from several types of vegetables in the rice cum vegetable production technology. In vegetable cultivation along with rice crop, the highest vegetable yield (14.5 t ha^{-1}) was recorded from white gourd + rice crop and the lowest vegetable yield (5.5 t ha^{-1}) was received from two treatments, yard long bean + rice crop (Table 01).

Published with open access at journalbinet.com
EISSN: 2312-7945,

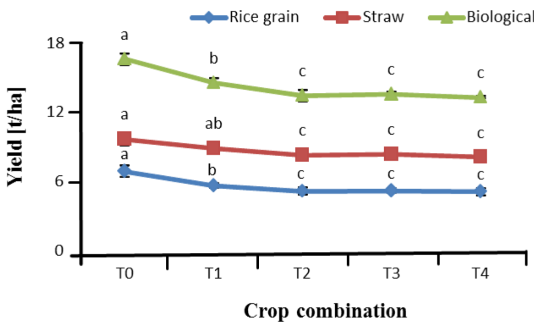

Figure 01. Grain yield, straw yield and biological yield of rice in different intercrop combonations (Data are means ±SD of *n*=5 experiments).

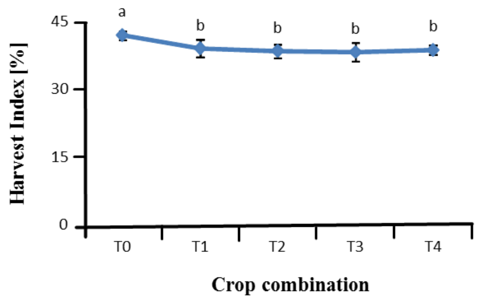

Figure 02. Harvest Index of rice in different intercrop combonations (Data are means ±SD of *n*=5 experiments).

Rice equivalent yield (REY), rice grain yield, total grain yield and LER

It was highly encouraging to observe that all the vegetable crops grown on the levee of rice plot gave significantly higher total rice equivalent yields compared to the sole of rice in spite of grain yield reduction due to the above ground effect of trellis as noted earlier. The significantly highest rice equivalent yields were obtained in the treatment of Snake gourd + rice combination (7.88 t ha^{-1}) and the lowest rice equivalent yield (6.35 t ha^{-1}) was found from the treatment white gourd + rice (Table 01). Bottle gourd + rice combinations produced moderate rice equivalent yields ranging from 6 – 7.9 t ha^{-1}. The highest rice grain yield was 6.9 t ha^{-1} in case of sole rice plot but in couple of the intercropping combinations rice grain yield was less (Table 01). After converting vegetable yield into rice equivalent yield, the total grain yield of each plot was more than the sole rice crop (6.9 t ha^{-1}). The highest value of total grain yield (13.15t ha-1) was found in the treatment of yard long bean + rice combination (Table 01). Beets (1994) demonstrated that corn and soybean intercropping in 1:1 combination gave maximum monetary return, greater total LER (equal to 1.35), and partial LERs of 0.7 and 0.65 for corn and soybean, respectively. Therefore, it seems that less competition between corn and soybean in 1:1 ratio compared other combinations resulting to equal partial LERs of greater than 0.5 (total LER>1) and greater mixture yield. Based on the LER value (Table 01), the result indicates that in all cases sole rice is less profitable than the plots provided with vegetable. The yield advantage (Total LER > 1.0) in multiple cropping compared monoculture in equal land area become more prominent. This result was similar to the findings of Kundu (2002).

Table 01. Vegetable yield and rice equivalent yield of the vegetable-rice cultivation system (Data are means ±SD of n=5 experiments)

Treatment	Vegetable Yield (t/ha)	Rice equivalent yield (G1) (t/ha)	Grain yield (G2) (t/ha)	Total grain yield (G1+ G2) (t/ha)	Land Equivalency Ratio (LER)
T_0	-	-	6.9	6.9a	1a
T_1	5.9	7.675	5.475	13.15c	4,12b
T_2	6.05	7.875	5.175	13.05c	4,18b
T_3	11.95	6.35	5.2	11.55b	4,04b
T_4	9.45	7.1	5.175	12.275bc	4,10b
Level of significance				*	**

Treatment means having similar letter (s) do not differ significantl * Indicates significant at 1% and ** Indicates significant at 5% level of significance; T_0 = Rice only, T_1= Yard long + rice, T_2= Snake gourd + rice, T_3= White gourd + rice, T_4= Bottle gourd + rice

Economic analysis

Total cost of production: The input costs, overhead costs and total cost of production of vegetable-rice production system was assessed. It is observed that vegetable cultivation on the levee of rice plot involved on extra expenditure that was marginally higher than only rice cultivation in the control plot. On average, only rice cultivation incurred 70,647.8 BDT ha^{-1}, while vegetable–rice intercropping cultivation added extra cost of production (Table 02). Result showed (Table 02) that the lowest cost of production (70,647.8 BDT ha^{-1}) was found in sole rice but in all other cases it was more. The main reason behind this is cost involvement for the production of two crop combinations.

Table 02. Cost of production of vegetable-rice intercropping (Data are means ±SD of *n*=5 experiments)

Treatment combination (Crop combination ×Trellis)	Input cost (BDT/ha)							Overhead cost			
		Material cost									
	Non material cost	Seed cost	Total fertilizer cost	Pesticide cost	Trellis cost	Total material cost (BDT/ha)	Total input cost (BDT/ha)	Interest of input cost @ 12% for growth period	Interest of the value of land 125000 (BDT/ha) @12% for growth period	Miscellaneous cost (BDT/ha)	Total cost production (BDT/ha)
T_0	28000	650	29280	700	-	30630	58630	3517	7500	1000	70647
T_1	30000	900	31000	850	17900	50650	80650	4839	7500	1300	94289
T_2	30000	900	31000	850	17900	50650	80650	4839	7500	1300	94289
T_3	30000	900	31000	850	17900	50650	80650	4839	7500	1300	94289
T_4	30000	900	31000	850	14000	46750	76750	4605	7500	1300	90155

Note:

T_0	=	Rice only	Organic manure	=	9.9 ton @2.00 (BDT/kg)	Curator	=	250 (BDT/ha)
T_1	=	Yard long bean + rice	Urea	=	270 kg @ 12.00 (BDT/kg)	Microthial	=	250 (BDT/ha)
T_2	=	Snake gourd + rice	TSP	=	180 kg @ 23.00 (BDT/kg)	Nogos100 EC	=	200 (BDT/ha)
T_3	=	White gourd + rice	MOP	=	160 kg @ 15.00 (BDT/kg)	Bamboo cost	=	100 (BDT/ha)
T_4	=	Bottle gourd + rice	Gypsum	=	70 kg @ 10.00 (BDT/kg)	Labour cost	=	80 (BDT/day)
			Zinc sulphate	=	10 kg @ 68.50 (BDT/kg)	Bullock pair	=	80 (BDT/day)

Gross return: Economic analysis showed that vegetable-rice cultivation gave higher gross return than that of sole rice (Table 03). Maximum gross return (2,80,650.00 BDT ha^{-1}) was obtained from the treatment combination yard long bean + rice and sole rice gave the minimum gross return (1,57,400.00 BDT ha^{-1}) (Table 03). Higher yield and economic returns in intercrops were also reported by Jana *et al.* (1999), Mandal et al. (1990), Zaman *et al.* (1999), and Moorthy and Das (1999).

Net return: Net return is an important indicator to select the profitable crop combination. Economic analysis of the vegetable-rice production showed that maximum net return over total cost of production was found (1,87,394.5 BDT ha^{-1}) in the treatment combination yard long bean + rice (Table 03). The lowest net return (86,752.2 BDT ha^{-1}) was obtained from sole rice (Table 03). The higher yield and economic returns in the intercrops were also reported by Mandal *et al.* (1990).

Benefit cost ratio (BCR)

Benefit Cost Ratios (BCR) positively progress while vegetable cultivation was included on the levee of rice. Sole rice gave BCR values of 1.23:1 and vegetable cropping earned much higher BCR values (Table 03). The highest BCR values of 2.01:1 was obtained from yard long bean + rice (Table 03). Other intercropping combinations yielded more than BCR 1.23:1of sole rice (Table 03). It was astonishing to note that all combinations of vegetable cropping on the ails of rice crop exceeded the sole rice cropping in terms of BCR values (Table 03). Although the highest vegetable production was found in white gourd + rice crop combination but the highest rice equivalent yield, gross return, net return and benefit cost ratio were found in the treatment combination yard long bean + and it was found comparatively more remunerative rice (Table 01-03). Though the vegetable production of this combination was not the highest one in this experiment but it was the best yard long bean production cultivated anywhere. Vegetable production on the levee of rice crop showed better performance than the sole rice in terms of rice equivalent yield, gross return, net return and BCR values (Table 1-3). The probable cause might be that the growth and development of white gourd was not so good in this

Published with open access at journalbinet.com

season. From both yield and economical point of view yard long bean was proved as the most suitable vegetable crop for cultivation with rice crop.

Table 03. Total cost of production and return of vegetable-rice cultivation system (data are means ±SD of *n*=5 experiments)

Treatment	Total cost of production (BDT/ha)	Return		Gross return (a+b) (BDT/ha)	Net return (BDT/ha)	Benefit cost ratio (BCR)
		Due to product (a) (BDT/ha)	Due to bi-product (b) (BDT/ha)			
T_0	70647.8	138000	19400	157400	86752.2a	1.23a
T_1	93255.5	263000	17650	280650	187394.5e	2.01e
T_2	93255.5	261150	16550	277700	184444.5d	1.98d
T_3	93255.5	231300	16800	248100	154844.5b	1.668b
T_4	93255.5	245500	16300	261800	168544.5c	1.81c
level of significance					**	**

Treatment means having similar letter (s) do not differ significantly ** Indicates significant at 1% level of significance; Yard long bean, Snake gourd and Yard long bean@26 BDT/ha, Rice grain@20 BDT/ha, Bottle gourd@15 BDT/ha, White gourd@10 BDT/ha and Rice straw@2 BDT/ha

IV. Conclusion

Multiple cropping systems clearly have the potential to increase the long-term sustainability of food production under low inputs in many parts of the world. A better exchange of information among ecologists, environmental scientists, agronomists, crop scientists, soil scientists and ultimately social scientists (e.g. exploring attitudes to uptake, and developing wider cost/benefit analyses) is prerequisite, so that the full potential of intercropping as a sustainable farming system can be realized. Consequently, the results of the present study revealed that, vegetable cultivation along with rice crop is remunerative in both yield and economical point of view. Sole rice cultivation is less profitable than the production of vegetable crops in the levee along with rice.

V. References

[1]. Adu-Gyamfi, J. J. , Myaka, F. A. , Sakala, W. D., Odgaard, R.,Vesterager, J. M. and Høgh-Jensen H. (2007). Biological nitrogen fixation and nitrogen and phosphorus budgets in farmer-managed intercrops of maize–pigeonpea in semi-arid southern and eastern Africa. Plant Soil, 295, 127–136. https://doi.org/10.1007/s11104-007-9270-0

[2]. Agrawal, R. L. (1995). Emerging trends in cropping system. Indian Farmers Digest, 10, 20-23.

[3]. Anon, A. (1990). Strip intercropping offers low-input way to boost yields. Sensible Agriculture, 7-8.

[4]. Beets, W. C. (1994). Multiple cropping of maize and soybean under a high level of crop management. Netherlands Journal of Agricultural Science, 25, 95-102.

[5]. Cardinale, B. J., Wright, J. P., Cadotte, M. W., Carroll, I. T., Hector, A., Srivastava, D. S., Loreau, M. and Weis, J. J. (2007). Impacts of plant diversity on biomass production increase through time because of species complementarity. Proceedings of the National Academy of Sciences, USA, 104, 18123–18128. https://doi.org/10.1073/pnas.0709069104

[6]. ERB (Economic Review of Bangladesh) (2007). Economic Advisory sub-division, Economic Div., Minis. Plan., Govt. People's Repub. Bangladesh, Dhaka. pp. 130.

[7]. Francis, R., Decoteau, D. R. (1993). Developing an effective southernpea and sweet corn intercrop system. HortTechnology, 3(2), 178-184.

[8]. Ghaffarzadeh, M., Prechac, F. G. and Cruse, R. M. (1994). Grain yield response of corn, soybean, and oat grown in a strip intercropping system. American Journal of Alternative Agriculture, 9, 171–177.

[9]. Gomez, K. A. and Gomez, A. A. (1984). Statistical Procedure for Agricultural Research. 2nd Ed., A. Willey and Inter-science Publication, John Willey and Sons, New York. pp. 97-111.

[10]. Harwood, R. R. and Higuita F. (1976). The Application of Science and Technology to Long-Range Solutions: Multiple Cropping Potentials. In: Scrimshaw N.S., Béhar M. (eds) Nutrition

and Agricultural Development. Basic Life Sciences, vol 7. Springer, Boston, MA. https://doi.org/10.1007/978-1-4684-2883-4_37
[11]. Hussain, M. M., Alam, M. S., Islam, M. A., Rashid, M. M., Islam, M. F., Rashid, M. A., Rzzaque, M. S., Mamin, M. S. I., Islam, M. R., Kabir, H., Parvin, S. and Mukul, H. R. (2006). In: Baqui, M. A.(eds). In: Proc. Twenty First BRRI-DAE Joint Workshop. 19-21 September 2006. BRRI, Joydebpur. pp.1-13.
[12]. Hossain, M A. and Siddique, M. N. A. (2015). Water-A Limiting Resource for Sustainable Agriculture in Bangladesh. EC Agriculture, 1, 2, 124-137.
[13]. Iannetta, P. P. M., Begg, G., James, E. K., Smith, B., Davies, C., Karley, A., LopezDel Egido, L., Hawes, C., Young, M., Ramsay, G., Birch, A. N. E., Valentine, T. A., Warburton, C., Goldring, A., Hughes, T., Sprent, J., Wolfe, M. and Rees, R. M. (2013). Sustainable intensification: a pivotal role for legume supported crop systems. Aspects of Applied Biology, 121, 73–82.
[14]. Inal, A., Gunes, A., Zhang, F. and Cakmak, I. (2007). Peanut/maize intercropping induced changes in rhizosphere and nutrient concentrations in shoots. Plant Physiology and Biochemistry, 45, 350–356. https://doi.org/10.1016/j.plaphy.2007.03.016
[15]. Jana, T. K., Mandal, B. K., Saha, S. and Saha, S. (1999). Effect of rice (*Oryza sativa*) groundnut (*Arachis hypogaea*) intercropping on yield complementarity. Indian Journal of Agricultural Science, 69(7), 513-515.
[16]. Johnson, W. G., Davis, V. M., Kruger, G. R. and Weller, S. C. (2009). Influence of glyphosateresistant cropping systems on weed species shifts and glyphosate-resistant weed populations. European Journal of Agronomy, 31, 162–172. https://doi.org/10.1016/j.eja.2009.03.008
[17]. Kundu, S. K. (2002). Vegatable production in Boro rice crop. M.S. Thesis, Dept. Agron., Bangladesh Agricultural University, Mymensingh. p. 64.
[18]. Kurata, T. (1986). A study on farming system in USSA. Quarterly Journal of Agro. Eco., 26: 179-205.
[19]. Laster, M. L. and Furr, R. E. (1972). Heliothis populations in cotton-sesame interplantings. Journal of Economic Entomology, 65(5),1524–1525. https://doi.org/10.1093/jee/65.5.1524
[20]. Li, L., Zhang, L. Z. and Zhang, F. Z. (2013). Crop mixtures and the mechanisms of overyielding. In: Levin SA, ed. Encyclopedia of biodiversity, 2nd edn, vol, 2. Waltham, MA, USA: Academic Press, pp. 382–395. https://doi.org/10.1016/B978-0-12-384719-5.00363-4
[21]. Li, Y. F., Ran, W., Zhang, R. P., Sun, S. B. and Xu, G. H. (2009). Facilitated legume nodulation, phosphate uptake and nitrogen transfer by arbuscular inoculation in an upland rice and mung bean intercropping system. Plant Soil, 315, 285–296. https://doi.org/10.1007/s11104-008-9751-9
[22]. Mandal, B. K., Dhara, M. C., Mandal, B. B., Das, S. K. and Naandy, R. (1990). Rice, mungbean, soybean, peanut and blackgram yields under different intercropping systems. Agronomy Journal, 32(6), 1063-1066. https://doi.org/10.2134/agronj1990.00021962008200060006x
[23]. Marshall, D. R., Brown, A. H. D. (1974). Stability of performance of mixtures and multilines. Euphytica, 22, 405-412. https://doi.org/10.1007/BF00022654
[24]. Martin, R., Smith, D. and Voldeng, H. (1987). Intercropping corn and soybeans. Sustainable Farming. REAP Canada. McGill University Macdonald Campus.
[25]. Mazaheri, D. and Oveysi, M. (2004). effects of intercropping of two corn varieties at various nitrogen levels. Iranian journal of Agronomy,71-76.
[26]. Moorthy, B. T. S. and Das, T. K. (1999). Performance of the intercroping systems of seasame with green gram and groundnut in rice-fallows in summer season under irrigated condition. Ann. Agric. Res. 20(3), 384-385.
[27]. Pathick, D. C. and Malla, M. L. (1979). Study on the performance of crops legume under monoculture and intercrop combination. Proceedings of the 6th Annual Maize Development Workshop, 23 May 1979, Nepal.
[28]. Powlson, D. S., Gregory, P. J., Whalley, W. R., Quinton, J. N., Hopkins, D. W., Whitmore, A. P., Hirsch, P. R. and Goulding, K. W. T. (2011). Soil management in relation to sustainable agriculture and ecosystem services. Food Policy, 36, S72–S87. https://doi.org/10.1016/j.foodpol.2010.11.025
[29]. Quigley, J. and Walls, L. (2003). Cost-Benefit Modelling for Reliability Growth. Journal of the Operational Research Society, 54 (12), 1234–1241. https://doi.org/10.1057/palgrave.jors.2601633

Published with open access at journalbinet.com
EISSN: 2312-7945,

[30]. Sultana, J., Siddique, M. N. A. and Abdullah, M. R. (2015). Fertilizer recommendation for Agriculture: practice, practicalities and adaptation in Bangladesh and Netherlands. International Journal of Business, Management and Social Research, 01(01), 21- 40. https://doi.org/10.18801/ijbmsr.010115.03

[31]. West, T. D., Griffith, D. R. (1992). Effect of strip-intercropping corn and soybean on yield and profit. Journal of Production Agriculture, 5, 107-110. https://doi.org/10.2134/jpa1992.0107

[32]. Zaman, S. S., Maleque, M. A. and Basak, N. C. (1999). Intercropping of brinjal, radish and red amaranth. Bangladesh Journal of Training Development, 12 (1&2), 121-125.

[33]. Zhang, F., Shen, J., Zhang, J., Zuo, Y., Li, L. and Chen, X. (2010). Rhizosphere processes and management for improving nutrient use efficiency and crop productivity: implications for China. Advances in Agronomy, 107, 1–32. https://doi.org/10.1016/S0065-2113(10)07001-X ; https://doi.org/10.2134/agronj14.0122

[34]. Zheng, Y., Zhang, F. and Li, L. (2003). Iron availability as affected by soil moisture in intercropped peanut and maize. Journal of Plant Nutrition, 26, 2425–2437. https://doi.org/10.1081/PLN-120025470

[35]. Zuo, Y. M., Li, X., Cao, Y. P., Zhang, F. S. and Christie, P. (2003). Iron nutrition of peanut enhanced by mixed cropping with maize: possible role of root morphology and rhizosphere microflora. Journal of Plant Nutrition, 26, 2093–2110. https://doi.org/10.1081/PLN-120024267

HOW TO CITE THIS ARTICLE?

Crossref: https://doi.org/10.18801/jbar.140217.148

APA (American Psychological Association)

Hossain, M. S., Kader, M.A. and Islam, N. (2017). Multiple cropping for sustainable and exaggerated agricultural production system. Journal of Bioscience and Agriculture Research, 14(02), 1202-1209.

MLA (Modern Language Association)

Hossain, M. S., Kader, M.A. and Islam, N. “Multiple cropping for sustainable and exaggerated agricultural production system”. Journal of Bioscience and Agriculture Research, 14.02(2017), 1202-1209.

Chicago and or Turabian

Hossain, M. S., Kader, M.A. and Islam, N. “Multiple cropping for sustainable and exaggerated agricultural production system”. Journal of Bioscience and Agriculture Research, 14 no. 02(2017), 1202-1209.