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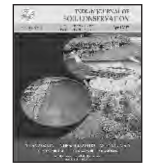

Productivity and profitability of maize (*Zea mays* L.) + vegetable intercropping systems using maize as live trellis and resource conservation in rainfed uplands of Odisha

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ABSTRACT

A trial was conducted during 2007 to 2009 at research farm of All India Coordinated Research Project for Dryland Agriculture, Phulbani in the North-Eastern Ghats Zone of Odisha with an objective to assess crop compatibility, productivity, profitability and sustainability of trailing vegetable + maize intercropping systems. Maize crop was sown during the second fortnight of June and vegetables were sown 15 days after sowing (DAS) of maize. Among the vegetables in maize based intercropping systems, ridge gourd (*Luffa acutangula* Roxb.) recorded the highest yield of 5.98 t ha^{-1} followed by cucumber (*Cucumis sativus* L.) (5.12 t ha^{-1}) and cowpea (*Vigna sinensis* Savi) (3.04 t ha^{-1}). The highest green cob equivalent yield of 16.60 t ha^{-1} was observed with maize + ridge gourd system which was at par with maize + cowpea system (16.52 t ha^{-1}). Among different systems, maize + ridge gourd was the most profitable with average net return of ₹ 45,000 ha^{-1} and B:C ratio of 2.18 followed by maize+cowpea with net return of ₹ 44,600 ha^{-1} and B:C ratio of 2.17. The highest net energy output was observed with maize + cowpea (13,244 MJ ha^{-1}) followed by maize + ridge gourd (10,363 MJ ha^{-1}). Maize + ridge gourd system recorded the highest rainwater use efficiency (RWUE) (14.52 kg ha-mm^{-1}) followed by maize + cowpea (14.45 kg ha-mm^{-1}) compared to sole maize of 9.30 kg ha-mm^{-1}. Nutrient uptake studies indicated that maize + cowpea system provided net positive nitrogen balance of 25.1 kg ha^{-1}. In all the intercropping systems, phosphorus recorded net negative balance and potassium recorded net positive balance at the end of cropping season irrespective of intercropping systems.

Key words:
Economics,
Energetics,
Nutrient balance,
Rainwater use efficiency,
System productivity,
Trailing vegetable

1. INTRODUCTION

Maize is one of the major cultivable crops in rainfed up and medium lands of interior districts of Odisha. Due to its growing demand for both industrial use and table purpose, the area under the crop is increasing at a faster rate. There is need to associate other profitable crops with maize to utilize the interspaces and increase land productivity. Moreover, the system minimizes risk (Woolley and Davis, 1991) and increases biological efficiency through exploration of large soil mass (Francis, 1989) along with socio-economic (Ofori and Stern, 1987), biological and ecological advantages (Fininsa, 1996) compared to monocropping. Cultivation of vegetable intercrops with maize is found productive and profitable system (Uddin *et al*., 2009 and Ali *et al*., 2015). The well drained rainfed lands in Eastern Ghats, Odisha are also suitable for growing a number of trailing vegetables such as cowpea, runner bean, ridge gourd, bitter ground, snake gourd and cucumber *etc.* Profitability of growing vegetables in the wide interspaces of maize during *kharif* season has also been advocated by Pandita, 2001. These vine vegetables need staking which is costly, cumbersome and labour consuming operation and its availability is limited in many places as a result of degradation in forest cover. Niringiye *et al*. (2005) reported limited adoption of climbing beans due to scarcity of staking material in Uganda despite the crop's higher yield potential compared to bush bean types. Cultivation of cowpea requires trellises, which increases production costs and maize and sunflower can be used as live trellises to reduce cost (Patricio *et al.,* 2011). Therefore, there is need to explore other alternatives like intercropping with maize, sunflower, cassava *etc.* that could substitute use of stakes. Maize being a C_4 plant, has quick growth habit, the plant comes to tasseling and silking stage within 6-7 weeks and attains the maximum plant height. Maize plants continue to provide support to trailing vegetables for about one month after harvesting of green or ripe cobs. By staggering planting time of maize and vegetable crops, maize plants can be used as live support. Niringiye *et al.* (2005) also reported growing two rows of beans in between maize rows, 10 days after maize emergence. Therefore, the present experiment was designed to assess crop compatibility, productivity, profitability and sustainability of intercropping systems comprising maize and trailing vegetables *viz.,* cowpea (*V. sinensis* Savi), runner bean (*Phaseolus coccinens* L.), cucumber (*C. sativus* L.), ridge gourd (*L. acutangula* Roxb.), bitter gourd (*Momordica charantia* L.) and snake gourd (*Trichosanthes anguina* L.).

2. MATERIALS AND METHODS

Field experiments were conducted for consecutive three years from 2007 to 2009 at research farm of All India Coordinated Research Project on Dryland Agriculture, Phulbani ($20^0$28' N latitude $84^0$14' E longitude and 736 m above msl) in the North-Eastern Ghats Zone of Odisha. It has a moist sub-humid climate with average pre monsoon, monsoon and post monsoon rainfall of 137, 1187, 116 mm, respectively. The soil order was alfisol and red lateritic with sandy loam texture. Organic carbon, pH, available N, P and K were 0.33%, 5.93, 115, 21 and 212 kg ha^{-1}, respectively.

The experiment was conducted with seven treatments in randomized block design with three replications. The performance of six intercropping systems comprising of maize+cowpea (CS1), maize+runner bean (CS2), maize+ cucumber (CS3), maize+ridge gourd (CS4), maize+bitter gourd (CS5) and maize+snake gourd (CS6) were compared against sole maize (CS7).

'Boom' maize was sown during the second fortnight of June to the first fortnight of July depending on onset of monsoon and vegetables were sown 15 DAS of maize every year. 'YB-7' cowpea, '*Raikia local*' runner bean, '*Nizam*' cucumber, '*Jaipur long*' ridge gourd, '*Nakhara local*' bitter gourd and '*Ganjam local*' snake gourd were used in the experiment. The planting was done in 7.2 x 3.6 m^2 plots in which maize was planted at 60 x 30 cm spacing and vegetables were planted in the same field after 15 days in the interspaces of maize at 120x120 cm spacing in basins. Before final land preparation, uniform dose FYM of 10 t ha^{-1} was applied to all the plots. Maize crop was given recommended fertilizer dose of 80 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1} out of which, 25% N , all P_2O_5 and 50% K_2O were applied as basal, 50% N and 50% K_2O as 1st top dressing at silking and rest 25% N as 2nd top dressing at tasseling stage. Cowpea and runner bean were given uniform fertilizer dose of 25 kg N + 70 kg P_2O_5 + 50 kg K_2O ha^{-1} which were applied as basal. Cucumber, bitter gourd and ridge gourd were given uniform fertilizer dose of 80 kg N + 50 kg P_2O_5 + 50 kg K_2O ha^{-1} out of which 50% N, all P_2O_5 and K_2O were applied as basal and rest 50% N as 1st top dressing after one month of planting. Maize was harvested as green cob during the first fortnight of September and vegetables were harvested from the second fortnight of August to the second fortnight of September.

Maize green cob yield and different intercrop crop yields were recorded from time to time. Maize Green Cob Equivalent Yield (MGEY) of all the systems was computed as per the prevailing market price of maize green cob and all the vegetables. System profitability was calculated by using prevailing market price of inputs and outputs. RWUE was computed by dividing crop yield by rainfall received during crop growth period according to Wani *et al.* (2013) and was expressed as kg ha-mm^{-1}. Energetics of different systems was calculated on the basis of equivalent-energy values as specified by Mohapatra and Pradhan (1993) and used in maize based intercropping systems by Padhi and Panigrahi (2006). Soil samples were collected from 0-15 cm depth before sowing and after harvest of crop every year. Plant samples were also collected and oven dried ground for chemical analysis for uptake studies. Soil samples were analysed for pH, organic carbon, available nitrogen, available phosphorus and available potassium as per standard procedure. Finally statistical analysis was done by following 'Analysis of Variance Technique'.

3. RESULTS AND DISCUSSION

Rainfall

Rainfall distribution during the three years of experimentation was ideal for growing *kharif* crops (Table 1). The total rainfall, seasonal rainfall and number of rainy days during crop growing season were higher in all three years of experimentation compared to normal average values of 25 years indicating a shift in rainfall pattern. After the onset of monsoon, there was enough soil moisture for germination of seeds and plant growth. The overall performance of crops were better during 2007 and 2009 when harvesting of vegetables continued up to mid October, but during 2008 heavy rainfall amounting to 124 and 110 mm consecutively for two days on 17th and 18th September destroyed the foliage of vegetables followed by a dry spell for about 11 days from 24th September to 4th October resulted in low yield of crops (Fig. 1). Scanty rainfall from 8th to 28th June during 2009 forced delayed sowing by about 20 days, but good rainfall distribution extended the harvesting of all the crops beyond mid October compensating the duration of crops and normal yield was recorded.

System Productivity

Different intercropping systems significantly influenced the maize green cob yield as well as vegetable yield (Table 2). The highest maize green cob yield of 8.52 t ha^{-1} was recorded with maize + snake gourd system followed by maize + cowpea (7.41 t ha^{-1}) and maize + runner bean (7.28 t ha^{-1}) which were significantly higher than other maize and vegetable systems. However, all the intercropping systems produced significantly less maize green cob yield than sole maize green cob yield of 10.63 t ha^{-1} as comparatively less area was allotted for maize in intercropping systems than sole maize. Among the vegetables, in maize based intercropping systems ridge gourd recorded the highest yield of 5.98 t ha^{-1} followed by cucumber (5.12 t ha^{-1}) and cowpea (3.04 t ha^{-1}). The lowest vegetable yield of 1.59 t ha^{-1} was recorded with runner bean. The highest green cob equivalent yield of 16.60 t ha^{-1} was observed with maize + ridge gourd system. Maize + cowpea system (16.52 t ha^{-1}) and maize + cucumber (14.18 t ha^{-1}) were at par with maize + ridge gourd for green cob equivalent yield. Sole maize recorded the lowest green cob yield of 10.63 t ha^{-1}. The maize stalk after harvest of green cob better served as live trellis and helped the trailing vegetables for more foliage growth and ultimately producing higher yield. The higher maize equivalent yield is attributed to higher vegetable production of ridge gourd and cucumber and higher price of cowpea. Hugar and Palled (2008) reported higher maize equivalent yield in maize+french bean inter cropping over sole maize.

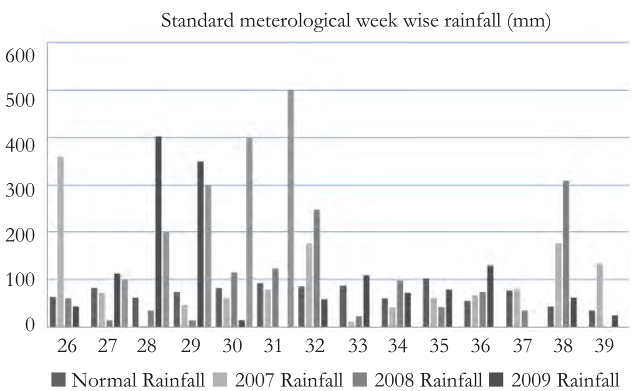


Fig. 1. Standard meteorological week wise rainfall pattern during crop growth period

Economics, Energetic and Water Use Efficiency (WUE)

The economics of different maize and vegetable intercropping systems indicated that maize + ridge gourd was the most profitable system with average net return of ₹ 45,000 ha^{-1} and B:C ratio 2.18 followed by maize + cowpea of ₹ 44,600 ha^{-1} and 2.17 compared to sole maize of ₹ 21,150 ha^{-1} and 1.66, respectively (Table 3). Maize + cowpea intercropping is also often practiced in the tropics (Mpangane *et al.*, 2004). The

Table: 1
Month wise rainfall data during crop growth period

Months	2007		2008		2009		Normal	
	Rainfall (mm)	No. of rainy days	Rainfall (mm)	No. of rainy days	Rainfall (mm)	No. of rainy days	Rainfall (mm)	No. of rainy days
June	424.0	10	270	17	124.8	9	188.7	9.1
July	188.4	7	263	16	881.6	23	350.4	14.73
August	363.8	18	422.4	23	321.4	19	383.2	14.95
September	465.4	18	449.3	15	220.2	12	228.2	10.95
Season Total	1441.6	53	1404.7	71	1548.0	63	1150.5	49.73
Year Total	1580.2	64	1531.8	76	1689.4	63	1407.3	65

Table: 2
Productivity of maize and vegetables in maize-based intercropping systems

Treatment	Maize green cob yield (t ha^{-1})				Vegetable yield (t ha^{-1})				Maize green cob equivalent yield (t ha^{-1})			
	2007	2008	2009	Pooled	2007	2008	2009	Pooled	2007	2008	2009	Pooled
Maize + Cowpea	7.42	6.91	7.88	7.41	3.51	2.26	3.35	3.04	17.95	13.69	17.93	16.52
Maize + Runner bean	7.59	6.62	7.62	7.28	1.70	1.35	1.71	1.59	14.39	12.02	14.46	13.62
Maize + Cucumber	6.75	5.47	5.71	5.98	5.08	4.86	5.43	5.12	14.88	13.25	14.40	14.18
Maize + Ridge gourd	3.80	5.43	4.66	4.63	7.24	5.65	5.07	5.98	18.28	16.73	14.80	16.60
Maize + Bitter gourd	7.08	6.30	7.14	6.84	3.06	1.34	2.14	2.18	16.26	10.32	13.56	13.38
Maize + Snake gourd	8.76	7.56	9.22	8.52	4.29	1.94	2.82	3.01	15.62	10.66	13.73	13.34
Sole Maize	10.33	10.13	11.44	10.63	-	-	-	-	10.33	10.13	11.44	10.63
Sem$\pm$	0.65	0.85	0.65	0.41	-	-	-	-	1.29	1.85	1.30	0.85
CD (P=0.05)	2.00	2.61	2.00	1.28	-	-	-	-	3.98	5.70	4.00	2.62

Price (₹ t^{-1}): Maize green Cob: 5,000; Cowpea: 15,000; Runner bean: 20,000; Cucumber: 8,000; Ridge gourd: 10,000; Bitter gourd: 15,000; Snake gourd: 8,000

Table: 3
Productivity, economics and energetics of various maize based intercropping systems (Pooled data of three years)

Treatments	Maize green cob yield (t ha^{-1})	Vegetable yield (t ha^{-1})	Maize green cob equivalent yield (t ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio	System energy input (MJ ha^{-1})	System energy output from MGEY (MJ ha^{-1})	System net energy return (MJ ha^{-1})	Energy productivity from MGEY (kg MJ^{-1})	Rain water use efficiency (kg ha-mm^{-1})
Maize + Cowpea	7.41	3.04	16.52	82600	44600	2.17	13188	26432	13244	1.25	14.45
Maize + Runner bean	7.28	1.59	13.62	68100	33100	1.95	13380	21792	8412	1.02	11.92
Maize + Cucumber	5.98	5.12	14.18	70900	32900	1.87	16167	22688	6521	0.88	12.41
Maize + Ridge gourd	4.63	5.98	16.60	83000	45000	2.18	16197	26560	10363	1.02	14.52
Maize + Bitter gourd	6.84	2.18	13.38	66900	31900	1.91	16197	21408	5211	0.83	11.71
Maize + Snake gourd	8.52	3.01	13.34	66700	31700	1.91	16197	21344	5147	0.82	11.67
Sole Maize	10.63	-	10.63	53150	21150	1.66	11920	17008	5088	0.89	9.30
Sem±	0.41	-	0.85	-	-	-	-	-	-	-	-
CD (P=0.05)	1.28	-	2.62	-	-	-	-	-	-	-	-

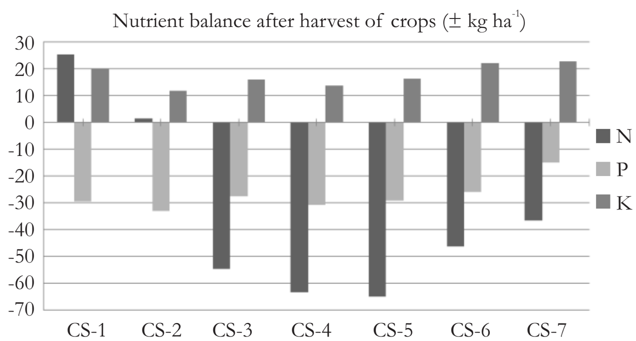
highest system energy output of 26,560 MJ ha^{-1} was observed with maize + ridge gourd followed by maize + cowpea (26,432 MJ ha^{-1}) but the highest system net energy return of 13,244 MJ ha^{-1} was observed with maize + cowpea followed by maize + ridge gourd (10,363 MJ ha^{-1}). Less energy input by low dose of nitrogenous chemical fertilizers in maize + cowpea system resulted in higher system net energy return and highest energy productivity of 1.25 kg MJ^{-1} from MGEY followed by maize + ridge gourd of 1.02 kg MJ^{-1} compared with sole maize of 0.89 kg MJ^{-1}. Higher system energy output, system net energy return and energy productivity were obtained with maize + ridge gourd and maize + cowpea intercropping systems because of higher system productivity compared to sole maize productivity. Prakash *et al.* (2007) also reported maximum system energy output, system net energy return and system energy use efficiency with maize + tomato + garden pea + french bean relay intercropping system because of higher system productivity. In analysing rainfed cropping systems, RWUE is an important criterion. Among different intercropping systems, maize + ridge gourd system recorded the highest RWUE (14.52 kg ha-mm^{-1}) followed by maize + cowpea (14.45 kg ha-mm^{-1}) and maize + cucumber (12.41 kg ha-mm^{-1}) because of higher system productivity compared to sole maize RWUE of 9.30 kg ha-mm^{-1}.

Nutrient Balance

Nutrient uptake studies (Table 4) indicated that maize + cowpea system though registered highest nitrogen uptake of 114.7 kg ha^{-1}, recorded net positive balance of 25.1 kg ha^{-1}. Maize + runner bean recorded net positive balance of only 1.4 kg ha^{-1} and all other intercropping systems recorded net negative balance of nitrogen in the soil at the end of cropping season (Fig. 2). Maize + bitter gourd and maize + ridge gourd were comparatively more exhaustive systems for nitrogen. In all the intercropping systems phosphorus recorded net negative balance. Maize + runner bean recorded the highest net negative phosphorus balance of -33.2 kg ha^{-1} and the lowest net negative balance was recorded with sole maize (-15.2 kg ha^{-1}). This is attributed to severe soil acidity in which most of the phosphorus got fixed. Potassium remained positive at the end of cropping season irrespective of intercropping systems which implies positive influence of the systems on potassium balance in soil. Additional application of nitrogen may be considered for maize + ridge gourd system. Reclamation of soil acidity through amendments is likely to augment phosphorus availability and meet the demand of maize and vegetable during the entire growth period. Selecting crops or varieties with different maturity time assists staggered harvesting (Thayamini and Brintha, 2010) and the peak period demand for nutrient, moisture, aerial space and light of component crops also differed (Enyi, 1977). Maize + cowpea intercropping system is beneficial for nitrogen poor soils (Vesterager *et al.*, 2008), increases the amount of nitrogen, phosphorus and potassium contents compared to mono crop of maize (Dahmardeh *et al.*, 2010).

Table: 4
Balance sheet of available N, P and K as affected by various maize based intercropping systems (Pooled data of three years)

Treatment	Total available nutrients comprising initial+added through different sources (kg ha^{-1})			Nutrient uptake (kg ha^{-1})			Available soil nutrient after last harvest (kg ha^{-1})			Net gain (+) / loss(-) of nutrient in soil (kg ha^{-1})		
	N	P	K	N	P	K	N	P	K	N	P	K
Maize + Cowpea	257	89.7	370.7	114.7	22.3	102.4	167.4	37.7	287.3	+25.1	-29.7	+19.7
Maize + Runner bean	257	89.7	370.7	100.4	21.1	98.7	158.0	35.4	283.7	+01.4	-33.2	+11.7
Maize + Cucumber	312	80.9	370.7	102.1	18.7	96.3	155.2	34.7	290.3	-54.7	-27.8	+15.9
Maize + Ridge gourd	312	80.9	370.7	96.0	18.2	100.1	152.4	31.7	284.1	-63.6	-31.0	+13.5
Maize + Bitter gourd	312	80.9	370.7	93.5	17.8	101.4	153.4	33.9	285.3	-65.1	-29.2	+16.0
Maize + Snake gourd	312	80.9	370.7	108.7	20.3	107.6	157.0	34.5	285.1	-46.3	-26.1	+22.0
Sole Maize	252	63.5	337.3	82.4	18.1	97.3	132.7	30.2	262.5	-36.9	-15.2	+22.5



CS1: Maize+Cowpea; CS2: Maize+Runner bean; CS3: Maize+Cucumber; CS4: Maize+Ridge gourd; CS5: Maize+Bitter gourd; CS6: Maize+Snake gourd; CS7: Sole maize

Fig. 2. Nutrient balance of different intercropping systems (kg ha^{-1})

4. CONCLUSIONS

Therefore, it is concluded that cowpea and ridge gourd are two more compatible intercrops with maize which produces higher maize equivalent yield and net return. These systems are also having higher RWUE, higher energy productivity and more sustainable as maize plant is used as live trellis in rainfed up and medium lands of Odisha where staking materials are scarce and costly. The authors acknowledge the financial support provided by ICAR through AICRPDA, Phulbani centre, OUAT for carrying out this study.

REFERENCES

Ali, M.R., Rahman, M.S., Asaduzzaman, M., Hossain, M.M. and Mannan, M.A. 2015. Intercropping maize with different vegetables. *Bangladesh Agron. J.*, 18(1): 49-52.

Dahmardeh, M., Ghanbari, A., Syahsar, B.A. and Ramrodi, M. 2010. The role of intercropping maize (*Zea mays* L.) and cowpea (*Vigna unguiculata* L.) on yield and soil chemical properties. *African J. Agric. Res.*, 5: 631-636.

Enyi, V.A.C. 1977. Grain yield in groundnut. *Expt. Agric.*, 13: 101-110.

Fininsa, C. 1996. Effect of bean and maize intercropping on bean common bacterial blight and rust diseases. *Int. J. Pest Manage.*, 42: 51-54.

Francis, C.A. 1989. Biological efficiency in multiple cropping systems. *Adv. Agron.*, 42: 1-42.

Hugar, H.Y. and Palled, Y.B. 2008. Effect of intercropped vegetables on maize and associated weeds in maize vegetable intercropping systems. *Karnataka J. Agric. Sci.*, 21: 159-161.

Mohapatra, P.K. and Pradhan, L. 1993. Energy relationship in intercropping of maize (*Zea mays*) with cowpea (*Vigna ungiculata*) and rice bean (*Vigna umbellate*). *Ind. J. Agric. Sci.*, 63(9): 581-583.

Mpangane, P.N.Z., Ayisi, K.K., Mishiyi, M.G. and Whitebread, A. 2004. Grain yield of maize grown in sole and binary cultures with cowpea and lablab in Limpopo province of South Africa. In: *Trop. Legumes Sust. Farming Sys. in Southern Africa and Australia.* (Whitebread, A.M. and B.C. Pengelly Eds.). Australian Centre for International Agricultural Research, Australia.

Niringiye, C.S., Ssekabembe, C.S. and Kyamanywa. 2005. Effect of plant population on yield of maize and climbing beans grown in an intercropping system. *African Crop Sci. J.,* 13(1): 83-93.

Ofori, F. and Stern, W.R. 1987. Cereal legume intercropping systems. *Adv. Agron.,* 41: 41-90.

Padhi, A.K. and Panigrahi, R.K. 2006. Effect of intercrop and crop geometry on productivity, economics, energetic and soil-fertility status of maize (*Zea mays*) - based intercropping systems. *Ind. J. Agron.*, 51(3): 174-177.

Pandita, A.K. 2001. Effect of vegetable intercropping on productivity, economics and energetic of maize (*Zea mays* L.). *Ind. J. Agron.,* 46: 204-210.

Patricio, A.B., Jose, A.S., Estrda, E., Teresa, M. and Rodrigues, G. 2011. Growth and yield of cowpea bean in relation to trellises. *Trop. Subtrop. Agroecosyst.,* 13: 307-315.

Prakash, V., Kumar, N., Bhattachariyya, R., Kumar, M. and Srivastva, A.K. 2007. Productivity, economics, energetic and soil properties of vegetables-based relay intercropping systems. *Ind. J. Agron.,* 52(4): 300-304.

Thayamini, H.S. and Brintha, I. 2010. Review on maize based intercropping. *J. Agron.,* 9(3): 135-145.

Uddin, M.J., Quayyum, M.A. and Salahuddin, K.M. 2009. Intercropping of hybrid maize with short duration vegetables at hill valleys of bandarban. *Bangladesh J. Agril. Res.,* 34(1): 51-57.

Vesterager, J.M., Nielsen, N.E. and Hogh-Jensen, H. 2008. Effect of cropping history and phosphorus source on yield and nitrogen fixation in sole and intercropped cowpea-maize systems. *Nutri. Cycl. Agroecosystems,* 80: 61-73.

Wani, S.P., Girish Chander, Saharwat, K.L. Dixit, S. and Venketeswarlu, B. 2013. Improved crop productivity and rural livelihoods through balanced nutrition in the rainfed semi-arid tropics. Resilient Dryland Systems Report No. 58, ICRISAT, Patancheru, Andhra Pradesh, India, 36p.

Woolley, J. and Davis, J.H.C. 1991. The Agronomy of intercropping with Beans. In: *Common beans: Research for crop improvement*. (Van Schoonhoven, A. and O. Voyeset Eds.). CAB International in association with CIAT, Wallingford, pp. 707-735.