ISSN: 0974 - 0376

The Ecoscan : Special issue, Vol. VII: 407-410: 2015
AN INTERNATIONAL QUARTERLY JOURNAL OF ENVIRONMENTAL SCIENCES
www.theecoscan.in

ENERGETICS OF MAIZE BASED INTERCROPPING SYSTEM

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KEYWORDS

Paired row
Uniform row spacing
Intercropping
Energy ratio
Energy productivity

Proceedings of National Conference on
Harmony with Nature in Context of
Bioresources and Environmental Health
(HORMONY - 2015)
November 23 - 25, 2015, Aurangabad,
organized by
Department of Zoology,
Dr. Babasaheb Ambedkar Marathwada University
Aurangabad (Maharashtra) 431 004
in association with
NATIONAL ENVIRONMENTALISTS ASSOCIATION, INDIA
www.neaindia.org

The Ecoscan
AN INTERNATIONAL QUARTERLY JOURNAL OF ENVIRONMENTAL SCIENCES

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ABSTRACT

A field experiment was conducted to study the energetics of maize based cropping systems during *kharif* 2005 and 2006 at Zonal Agricultural Research station, Navile, Shimoga. The experiment consisted of sole crop treatment of maize, field bean, redgram, soybean and frenchbean along with maize based intercropping systems under uniform row spacing (URS) and paired row (PR) system. Among sole crop treatments, higher energy ratio (20.56) and higher energy productivity (1215.5g MJ^{-1}) was recorded by sole crop of maize under uniform row spacing. Among intercropping treatments higher energy ratio (16.6) was recorded in maize + French bean system (grain) and higher energy productivity was recorded in maize + field bean var. local system (999.6 g MJ^{-1}).Significantly higher energy spent to produce one tonne of the produce was with sole crop of French bean raised for grain purpose (19456.5 MJ $tonne^{-1}$). The lower energy required to produce one tonne of the produce was estimated with sole crop of maize sown at URS (829.3 MJ $tonne^{-1}$).Among all type of maize based cropping systems, sole crop of maize with URS is more energy efficient. Among intercropping treatments Maize (PR) + Field bean var. Local is more energy efficient, maize based intercropping system and higher maize equivalent yield (5510 kg ha^{-1}) also recorded in same treatment.

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INTRODUCTION

Maize (*Zea mays* L.) is considered as an economically important cereal crop, major ingredient for food, feed and other products. It assumes an important role next to rice and wheat in the farming sector and macro-economy of the agrarian countries. It is third most important cereal crop in India after rice and wheat that occupied about 9.43 million hectares producing 24.35 million tones with an average productivity of 2.6 tones ha^{-1} during 20013-14 (*Anon*., 2015). Maize is one such crop which provides opportunity for inclusion of intercrops because of the wide row space provided to the crop and also because of the plasticity of the crop to row spacing (Sai sravan and Ramana murthy, 2014). In Southern Transitional Zone of Karnataka, where, the crop is cultivated during rainy season, the amount and distribution of rainfall also favours for the inclusion of short duration intercrop. Soybean is one of the recommended legumes for intercropping in maize. Red gram and field bean needs to be evaluated under intercropping with maize, as some preliminary studies elsewhere are promising. Agro-ecosystem productivity evaluation using energy budgeting is important and interesting (Tuti *et al.,* 2011). Energy is one of the most important indicators of crop performance. The net energy of a cropping system can be quantified for sound planning of sustainable cropping systems (Chaudhary *et al.,* 2006). Yield and economical parameters increased linearly as level of fertility increased, while reverse trend is observed with energy use efficiency, energy productivity and energy intensiveness (Billore *et al.,* 2005). The share of agriculture in national energy consumption has been rising consistently over the last three decades. Presently, it accounts for nearly a quarter of the country's electric consumption (Singh *et al.*, 1997). Yield of different crops can be increased up to 30% by using optimal level of energy input (Chaudhary *et al.,* 2006).

The energy-agriculture relationship is becoming more and more important with the intensification of the cropping systems in resource scarce situations. The energy is invested in various forms such as mechanical (farm machines, human labor, animal draft), mineral fertilizer, pesticides, herbicides, electrical, etc. Sufficient availability of the right energy and its efficient use are prerequisites for improved agricultural production (Chaudhary *et al.,* 2009). Therefore, in order to identify energy efficient cropping systems and for satisfactory energy output and net return, the present study has been undertaken with the novel maize based cropping system. The aim of this study was to assess and compare the system productivity and energy indices of different maize based cropping systems in Southern Transition Zone of Karnataka.

MATERIALS AND METHODS

The experiment was conducted during *Kharif* 2005 *and* 2006 at Zonal Agricultural Research Station, Navile,Shimoga, to evolve sustainable, energy efficient maize based cropping system in Southern Transition Zone of Karnataka at 14°00' North latitude, 75°40' East longitude and at an altitude of 650 m above the mean sea level. The experiment consisted of 18 treatments *viz*. T_1 Sole maize at Uniform Row Spacing (URS) of 60 cm, T_2 Sole maize at paired row of 60 cm, T_3 Sole soybean (Vr.

KHSb 2), T_4 Sole soybean (Vr. KB- 79), T_5 Sole red gram (Vr. Hyd- 3c), T_6 Sole red gram (BRG -1), T_7 Sole field bean (Var.- HA_3), T_8 Sole field bean (Local Avare), T_9 French bean (Var. Arka Komal) (Vegtable), T_{10} French bean (Var. Arka Komal) Grain, T_{11}Maize (PR) + Soybean var. KHSb-2, T_{12} Maize (PR) + Soybean var. KB- 79, T_{13}Maize (PR) + Red gram var. Hyd - 3c, T_{14} Maize (PR) + Red gram var. BRG-1 T_{15} Maize (PR) + Field bean var. HA- 3, T_{16} Maize (PR) + Field bean var. Local, T_{17} Maize (PR) + French bean var. Arka Komal V), T_{18} Maize (PR) + French bean var. Arka Komal (G).

Energetics in cropping systems is an approach to gauge, quantify and determine relationship between input and output to augment energy use efficiency and crop productivity. The equivalent-energy values as specified by Mittal and Dhawan (1988) were used for calculating energetics. Here output energy was estimated for biological obtained as well as for economical yield. Energy ratio indicates energy use efficiency of an enterprise or cropping system. It gives output energy units for every unit of input energy. Higher is the ratio higher the efficiency of the system. Energy ratio was calculated by using the formula:

ER= (Output energy MJ/ha)/(Input energy MJ/ha)

Specific energy is defined as the energy that is required to produce one unit of output and expressed in MJ kg^{-1}. It was calculated by dividing total energy MJ $ha^{-1}$with total out put in tones ha^{-1}.

Another index the energy productivity is defined as the quantity of output produced per unit of input energy and expressed in g. MJ^{-1}. It was calculated by using the formula:

Energy productivity = (Output in g. ha^{-1}/Total energy used MJ ha^{-1})

RESULTS AND DISCUSSION

Energetics

The output and input energy ratio (ER) worked out for different treatments are presented in Table.2. Higher energy ratio (output energy per unit of input energy) was recorded by sole crop of maize sown at URS (20.56) closely followed by sole crop of maize under paired system (19.29). This was true in both 2005 and 2006. Significantly, lower energy ratios were obtained under sole crop of intercrops among different intercrop treatments (T_{12}-T_{19}) highest energy ratio of 16.6 was obtained in maize + French bean (grain) was followed by maize + field bean var. local (16.29). The higher energy ratio in these treatments is due to higher stover yield of maize and lesser input energy compared to intercrop treatments due to fewer requirements of chemical fertilizers and labour for weeding and harvesting. The lowest input energy under sole cropping compared to mixed stands was also reported by Mohapatra and Pradan (1993). Further, they also reported 15.55 per cent higher input energy requirement for intercropping in either cowpea or rice bean in both sole or paired row planting of maize.

The specific energy worked out as influenced by various treatments resulted in significant variations in energy consumed to produce one tonne of biological yield. Significantly higher energy spent to produce one tonne of the produce was with sole crop of French bean raised for grain purpose (19456.5 MJ $tonne^{-1}$). The lower energy required to produce one tonne of the produce was estimated with sole crop of maize sown at URS (829.3 MJ $tonne^{-1}$) and sole crop of maize sown under paired row system (891.8 MJ $tonne^{-1}$). In all, the specific energy recorded across intercrop treatments was found at par to specific energy recorded under sole crop of maize (Table.2).

The energy productivity as proposed by Fluck (1979), measures energy utilization in an agricultural system. It is the quantity of product per unit of input energy conveniently expressed in kg MJ^{-1}. The sole crop of maize sown at URS of 60 cm resulted in significantly higher productivity per unit of energy used (1215.5 g MJ^{-1}) than other treatments (Table 2).

Table 1: Grain yield of maize and intercrops and equivalent yield (MEY) spacing as influenced by different maize based intercropping systems(kg ha^{-1}) (pooled data of 2005-06)

Treatment	Maize	Intercrop	MEY	
T_1 Sole maize at URS of 60 cm	5041	-	5041	
T_2 Sole maize at PR of 45-75-45 cm	4784	-	4784	
T_3 Sole soybean (Vr. KHSb 2)		-	613	T_4
Sole soybean (Vr. KB- 79)	-	653	2139	
T_5 Sole red gram (Vr. Hyd- 3c)	-	1136	3172	
T_6 Sole red gram (BRG -1)	-	1389	3865	
T_7 Sole field bean (Var.- HA_3)	-	556	1538	
T_8 Sole field bean (Local Avare)	-	975	2932	
T_9 French bean (Var. Arka Komal) (Vegtable)	-	996	1562	
T_{10} French bean (Var. Arka Komal) Grain	-	523	1820	
T_{11}Maize (PR) + Soybean var. KHSb-2	3901	164	4434	
T_{12}Maize (PR) + Soybean var. KB- 79	3541	224	4261	
T_{13}Maize (PR) + Red gram var. Hyd - 3c	3463	400	4581	
T_{14}Maize (PR) + Red gram var. BRG-1	3658	472	4981	
T_{15}Maize (PR) + Field bean var. HA- 3	3940	118	4210	
T_{16}Maize (PR) + Field bean var. Local	3645	633	5510	
T_{17} Maize (PR) + French bean var. Arka Komal V)	3975	358	4524	
T_{18}Maize (PR) + French bean var. Arka Komal (G)	4096	236	4929	
S. Em ±			104	
C.D. (P=0.05%)			287.6	

Table 2: Energetics of different maize based intercropping systems pooled data of 2005-06

Treatment	System Energy ratio	Specific energy (MJ/t)	Energy productivity for biological yield (g MJ^{-1})
T_1 Sole maize at URS of 60 cm	20.56	829.3	1215.5
T_2 Sole maize at PR of 45-75-45 cm	19.29	891.8	1141.6
T_3 Sole Soybean (Vr. KHSb 2)	2.98	4582.4	223.0
T_4 Sole Soybean (Vr. KB- 79)	3.10	4331.6	233.3
T_5 Sole Red gram (Vr. Hyd- 3c)	9.10	1878.7	536.3
T_6 Sole Red gram (BRG -1)	9.95	1721.5	590.6
T_7 Sole field bean (Var.- HA_3)	4.37	3231.3	332.2
T_8 Sole field bean (Local Avare)	8.18	1615.5	621.3
T_9 Frenchean (Var. Arka Komal) Vegetable	1.55	7072.6	180.2
T_{10} French bean (Var. Arka Komal) Grain	1.96	19456.5	147.5
T_{12} Maize (PR) + Soybean var. KHSb-2	15.42	1113.2	919.9
T_{13} Maize (PR) + Soybean var. KB- 79	14.32	1217.3	856.3
T_{14} Maize (PR) + Red gram var. Hyd - 3c	14.86	1179.8	876.1
T_{15} Maize (PR) + Red gram var. BRG-1	15.90	1105.1	938.3
T_{16} Maize (PR) + Field bean var. HA- 3	15.67	1126.3	933.2
T_{17} Maize (PR) + Field bean var. Local	16.29	1024.0	999.6
T_{18} Maize (PR) + French bean var. Arka Komal V)	15.79	1093.9	957.1
S. Em ±	0.29	235.76	23.56
C.D. (p=0.05%)	0.80	53.2	5.24

URS : Uniform Row Spacing; PR : Paired Row System

The next best treatment was again sole crop of maize planted under paired row system (1141.6 g MJ^{-1}) which was also significantly superior over all intercropping systems. All intercrops tested sown under their pure stands have recorded significantly lower energy productivity compared to respective intercropping systems. Among intercrop treatments (T_{12}-T_{19}), the highest energy productivity was achieved by maize + field bean var. local (999.6 g MJ^{-1}) which was due to significantly higher biomass and maize equivalent yield (5510 kg ha^{-1}) in this treatment (Rajesh Kumar *et al.*, 2015).Among all type of maize based cropping systems, sole crop of maize with URS is more energy efficient. Among intercropping treatments Maize (PR) + Field bean var. Local is more energy efficient.

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