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Evaluation of Diversified Cropping Systems for Their Energetic's and Economics Under Different Nutrient practices

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ABSTRACT
A field experiment was conducted to evaluate the production potential, their energetics and economics of efficient cropping systems under different nutrient management practices during 2011-12 to 2012-13. Among the cropping systems, groundnut (Arachis hypogaea L.) – onion (Allium cepa L) cropping system recorded significantly maximum groundnut equivalent yield (7.82 t / ha), production efficiency (35.06 kg / ha /day) and economic efficiency (Rs.842.46 / ha / day) than rest of the cropping systems. In energetic, groundnut-chickpea (0.82 t/ ha) recorded significantly higher protein than groundnut-wheat but at par with groundnut-onion, while carbohydrates (5.41 t/ ha) and fats (0.81 t/ ha) were registered higher with groundnut-onion cropping system. Application of fertilizer as per STCR equation to preceding crop kharif groundnut registered significantly higher protein (0.95 t/ha), carbohydrate (4.20 t/ ha) and fat (0.88 t/ ha) than control treatments. Similarly, groundnut (Arachis hypogaea L.)– onion (Allium cepa L) cropping system obtained significantly maximum gross (Rs. 283156 / ha) and net monetary returns (Rs. 188095 / ha) and B:C ratio (2.98) but groundnut-chickpea cropping system was registered significantly higher energy output-input ratio (9.54), energy balance per unit input (8.85) and energy intensiveness (2.59/MJ) on pooled mean. At the end of the 2 years cropping cycles, groundnut (Arachis hypogaea L.)- onion (Allium cepa L) cropping system found to be most efficient and suitable for achieved maximum productivity, energetic and monetary returns with application of fertilizer as per soil test crop response (STCR) equation.
Keywords: *Evaluation, Energetics and Economics, Nutrient management, Production efficiency.*

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INTRODUCTION

In the changing agricultural scenario, agriculture in India has to face new challenges to compete at the global level in many agricultural commodities. Indian agriculture is now facing second generation problems like raising or lowering of water table, nutrient imbalance, soil degradation, salinity, resurgence of pests and diseases, environmental pollution and decline in farm profit. Recently in India, farmers are practicing Rice-wheat, Maize-wheat, Maize-chickpea, Cotton-wheat, Cotton-summer groundnut, Groundnut-wheat, Soybean-wheat and Soybean-onion cropping systems for higher productivity. Crop diversification has been recognized as an effective strategy for achieving the objectives of food security, nutritional security, income growth, poverty alleviation and employment generation, judicious use of natural resources like land and water for sustainable agricultural development and environmental improvement. Groundnut (*Arachis hypogaea* L.) is the premier oilseed crop of India, occupies an area of 6.7 million/ ha and contributes 7.3 million tonnes towards oilseed production. India stands first in area and second in production and fifth in productivity (995 kg/ ha). The challenge of producing 58.56 million tonnes of oilseeds to meet the requirement of 1.13 billion Indian populations. A gap of about 33.82 million tonnes of oilseeds needs the growth rate of 5.56 per cent per annum in the production. Area under oilseeds is not likely to increase in the near future and meeting this gap is the most important problem in India today. Groundnut is an unpredictable legume, since its response to nutrient application is always not optimistic, excessive application of nitrogen and potassium often resulted in excessive vegetative growth considering the availability of the major elements in the soil and quantum of losses due to leaching or fixation of the individual elements. The review is aimed to have better understanding of different cropping system with inclusion of legume and different nutrient management treatments which

can be helpful for increasing the production of *kharif* groundnut and their residuals effects on succeeding crops. It also increases the production potential and energetics and sustainability of cropping systems. Therefore, an investigation was undertaken to find out efficient cropping systems and their energetics under different nutrient management treatments.

MATERIALS AND METHODS

A field experiment was conducted during 2011-12 to 2012-13 at Post Graduate Institute, Research Farm, MPKV, Rahuri (19° 48' N latitude and 74° 32' E longitude and 495 meter above mean sea level). The average maximum and minimum atmospheric temperatures were 32.4°C and 15.5°C, respectively. The average relative humidity was 62% in morning and 42.5% in the evening. Rainfall received during 2011-12 and 2012-13 was 527.8 and 424.0 mm, respectively (average 520.0 mm). The soil of the experimental site is sandy clay loam in texture (clay- 44.45%, Silt-33.20% and Sand- 21.42%) with having pH 8.2 and EC 0.29 dS/ m and organic carbon 0.54 % in top of 15 cm soil. The available nitrogen, phosphorus and potassium were 172.11, 18.02, 427.0 kg/ ha and moderate in Fe, Mn, Zn and Cu were 6.89, 9.51, 0.62 and 3.41 µg/ g of soil. The field capacity, bulk density and permanent wilting point of the surface (0-15 cm) soil were 32.23% on volume basis, 1.32 Mg/m^3 and 16.21%, respectively. The experiment was laid out in randomized block design during *kharif* season with nine replications and strip plot design in *rabi* season with three replications. The treatment tested include 3 cropping systems *viz.,* groundnut -onion, groundnut-wheat and groundnut-chickpea with 4 nutrient management practices *viz.,* recommended dose of fertilizer, fertilizer dose as per soil test, fertilizer dose as per STCR equations (25 q/ha of yield target) and control as main plot treatment, whereas 3 fertilizer levels *viz.,* 100 % RDF, 75% RDF and 50 % RDF as sub plot treatments. The yield target equation was used for *kharif* groundnut as prescribed by[9]. Targeted yield equations for FN (kg/ ha)= 4.16 T – 0.37 SN; FP_2O_5 (kg/ ha) = 4.96 T – 4.36 SP; FK_2O (kg/ ha)=3.14 T – 0.16 SK; Where, FN, FP_2O_5 and FK_2O = Fertilizer in kg /ha; 'T' = Target yield (q/ ha), SN = Soil available nitrogen (kg/ ha), SP = Soil available phosphorus (kg/ ha), SK= Soil available potassium (kg/ ha). Groundnut was sown in third week of June and harvested at second week of October. The winter crops *viz.,* onion, durum wheat and chickpea were sown in second week of November and harvested in third and fourth week of March during both the years. The intercultural operations and and plant protection measures were carried out as per the recommendations of respective crops. In experimental plot, 5 plants were selected randomly from the second row of each plot in *kharif* groundnut, *rabi* onion, chickpea and per m^2 area of wheat was selected after leaving the first row of the each plot for measurement of growth and yield attributes. The economic yield of the component crops was taken into account over the years and then expressed as productivity (t/ ha) of different cropping systems. The cost of cultivation was calculated by taking into account the prevailing prices of inputs. To compare different crop systems, the yields of all crops were converted into groundnut equivalents (GEs) on market price basis. Production efficiency in terms of kg/ha/day was worked out by total economic yield in terms of PE in a crop rotation divided by total duration of crops in a system [14]. Economic efficiency in terms of Rs. /ha/day was worked out by .dividing the net returns of the system by total duration of crops in an agricultural year [8]. Land utilization index was calculated by dividing total duration of respective crops with 365 days [14]. Net returns were the difference between the gross and total cost of cultivation of the component crops. B:C ratio (Returns per rupees invested) of a system was expressed as net returns per rupees spent. The input and output energies were calculated by energy conversion factors (Table 2) for inputs like labour, fuel, fertilizers, seeds, machineries, pesticides and irrigations etc. used in the respective crop system[1][6]. System net energy returns was calculated by deducting input energy from output energy. Energy output- input ratio was worked out by energy output divided by energy input. Energy balance per unit input was calculated by system net energy returns divided by input energy. Energy intensiveness was worked out by dividing energy output by cost of cultivation incurred in crop production. Statistical analysis of the data was carried out using standard analysis of variance.

RESULTS AND DISCUSSION

Yield of kharif groundnut

The growth and yield attributes of *kharif* groundnut were influenced significantly due to different nutrient management treatments during pooled mean of years. Application of fertilizer as per soil test crop response (STCR) equation (40-50-20 kg NPK/ ha) to *kharif* groundnut registered significantly higher growth and yield attributes were reflected in significantly higher dry pod yield (2.35 t / ha) and protein content. The yield target of 2.5 t /ha was achieved by STCR equation with less than 10 % variation (-5.8 %). The fertilizer dose as per soil test was found second best treatment of 1.93 t/ha. (Table 3). This is because of balanced nutrition also increases the chlorophyll content in leaves, which increases the

photosynthetic rate and translocation of photosynthesis towards reproductive parts i.e. pods. Similarly, the groundnut being a legume crop having more nitrate reductase activities in root which is beneficial for peg formation and pod development stage [2] [15].

Yield of rabi crops

In Onion, application of fertilizer as per STCR equation to preceeding crop *kharif* groundnut registered maximum and significantly higher yield of onion bulb (59.76 t/ ha) and it was 9.75 % higher than recommended dose of fertilizer. Application of 100 per cent recommended dose fertilizer (RDF: 100-50-50 kg NPK / ha) to succeeding onion crop preceded by *kharif* groundnut registered significantly higher bulb yield (48.89 t/ ha) and it was 4.46 % higher than 75 % RDF and 16.65 % higher than 50 % RDF (Table 3). This might be because of the residual effect of preceding crop maintaining soil organic matter, major and micronutrients, which increases the uptake of these nutrients and accelerating the physiological activities in crop for improving growth attributes. Similarly, it was also increases the translocation of photosynthates towards onion bulb resulted in increasing the weight of bulb [4] [5] [11].

Wheat: The growth and yield attributes of wheat were influenced significantly due to residual effect of *kharif* groundnut. Application of fertilizer as per STCR equation to preceding crop *kharif* groundnut registered significantly maximum grain yield of wheat (4.26 t / ha) and it was 8.28 % higher than recommended dose of fertilizer on pooled mean basis (Table 3). In application of 100 % RDF (120-60-40 kg NPK / ha) to wheat crop during *rabi* season recorded significantly maximum grain yield (3.64 t/ ha) and it was 14.86 % higher than reduced level of fertilizer i.e. 50 % RDF but at par with 75 % RDF (Table 3). This indicate that growing of wheat crop after *kharif* groundnut saves 25 % RDF because of balance nutrition to *kharif* groundnut through STCR equation creates favourable environment in the root rhizosphere of wheat crop to absorb more nutrients and moisture by improving the nutrient use efficiency [7][10][16].

Chickpea: The residual effect of *kharif* groundnut showed the favorable response for increasing the growth and yield attributes. The fertilizer management as per STCR equation registered significantly higher grain yield of chickpea (2.89 ha) was achieved and it was 11.38 % higher than recommended dose of fertilizer (Table 3). Application of 100 % RDF (25-50-00 kg NPK/ ha) to chickpea crop exhibited significantly maximum growth and grain yield of chickpea and recorded significantly higher grain yield of 2.65 t/ha and at par with 75 % RDF (Table 3). This indicates that, 25 per cent of fertilizer dose was saved, when chickpea grown after *kharif* groundnut [10][12][13].

Groundnut equivalent yield: Among the cropping systems, groundnut–onion cropping system recorded significantly maximum groundnut equivalent yield of 7.82 t / ha and it was 138.89 % higher than groundnut-wheat system and 92.68 % higher than groundnut-chickpea system. The nutrient management as per STCR equation proved it's superiority by recording maximum groundnut equivalent yield of 6.69 t/ ha and it was 19.25 % higher than than recommended dose of fertilizer (Table 3). Application of 100 % RDF to succeeding *rabi* crops preceded by *kharif* groundnut registered significantly higher groundnut equivalent yield than 50% RDF and at par with 75 % RDF.

Enegetics: Evaluation of different cropping systems through energetic is appreciated these days as it is more stable and meaningful and it indicates the energy yield from the system which does not fluctuates with the market prices since it is based on nutritional value of the system. Unlike, groundnut-equivalent yields, energetics revealed different pattern, where in protein yields were significantly higher in groundnut-chickpea (0.82 t/ ha) than groundnut-wheat but at par with groundnut-onion because of higher protein content in groundnut and chickpea grains as compared to other crop study (Table 1, 2 and 3), while carbohydrates (5.41 t/ ha) and fats (0.81 t/ ha) were registered higher with groundnut-onion cropping system with higher crop yields with respective crops. Application of fertilizer as per STCR equation to preceding crop *kharif* groundnut registered significantly higher protein (0.95 t/ha), carbohydrate (4.20 t/ ha) and fat (0.88 t/ ha) than control treatments. Application of fertilizer did not differ significant differences [3].

***Land use efficiency*:** The highest land-utilization index (Table 4) was observed with groundnut-onion cropping system (59.84 %) since these crops occupied the land for longest duration (218 days). The least land-utilization index was registered in groundnut-chickpea cropping system (59.84 %) which occupied the land for 209 days. Application of fertilizer as per STCR equation to preceding *kharif* groundnut were recorded highest 59.43% (217 days) and lowest in control 57.52 (210 days) treatments land-utilization index during pooled mean.

Production efficiency: Among the cropping systems, groundnut–onion cropping system registered significantly higher production efficiency of 35.06 kg / ha /day than groundnut-wheat and groundnut-chickpea cropping systems. The nutrient management treatments as per STCR equation registered significantly higher production efficiency of 30.25 kg / ha /day and it was 17.20 % higher than

recommended dose of fertilizer. Application of 100 % RDF to succeeding crop during *rabi* season registered significantly higher production efficiency than 50 % RDF and at par with 75 % RDF on pooled mean (Table 4).

Economic efficiency: The groundnut-onion cropping system recorded significantly higher economic efficiency of Rs. 842.46/ ha/day than groundnut-wheat and groundnut-chickpea cropping systems. Application of fertilizer as per STCR equation to *kharif* groundnut recorded significantly higher economic efficiency of Rs. 713.34/ha/ day than rest of the nutrient management and control treatment. The economic efficiency of different cropping systems was also influenced by different fertilizer levels to succeeding crops. Application of 100 % RDF to succeeding crop during *rabi* season recorded significantly higher economic efficiency than 50 % RDF level and at par with 75 % RDF (Table 4). This is because of higher yield and biomass production with higher level of fertilizer.

Table 1. Agronomic practices followed for the different crops and values of energetics per 100 g edible portion of the crop.

Crop	Variety	Spacing	NPK (Kg/ha)	Number of irrigations	Protein	Carbohydrate	Fat
Groundnut	JL-501	30 cm x 10 cm	25-50-00	3	25.09	26.67	43.71
Onion	N 2-4-1	15 cm x10 cm	100-50-50	5	1.01	11.3	0.7
Wheat	Trimbak	22.5 cm line	120-60-40	5	9.51	73.86	1.61
Chickpea	Digvijay	30 cm x 10 cm	25-50-00	3	22.39	53.81	1.15

Table 2. Energy conversion factors used in study.

Power source	**Unit**	**Equivalent Energy (MJ)**
Human labour		
Adult man	Man hour	1.96
Adult woman	Woman hour	1.57
Animal labour		
Bullock medium	Pair hour	10.10
Machinery		
Electric motor	kg	64.80
Self propelled machine	kg	68.40
Seed	kg	62.70
Wood	kg	30.80
Chemical fertilizer		
Nitrogen	kg	60.60
P_2O_5	kg	11.10
K_2O	kg	6.70
Chemical	kg	120.00
Farm yard manure (dry)	kg	0.30
Diesel	Litre	56.31
Electricity (1.7630 kw/ h)	Kw / ha	11.93
Seed/output		
Wheat	(dry)kg	14.5
Chickpea	(dry)kg	15.1
Oilseeds	(dry)kg	25.0
Onion	(dry)kg	0.06
Byproducts		
Fodder	(dry)kg	18.0
Straw	(dry)kg	12.5
Stalk	(dry)kg	18.0
Dung	(dry)kg	18.0
Fuel wood		
Hard	(dry)kg	20.70
Soft	(dry)kg	18.90
Kerosene	Litre	41.30

Energy studies: The groundnut-chickpea cropping system was registered significantly higher energy output-input ratio (9.54), energy balance per unit input (8.85) and energy intensiveness (Rs. 2.59/MJ). The groundnut-chickpea cropping system was recorded maximum yield with minimum input energy than groundnut-onion and groundnut-wheat cropping system. Application of fertilizer as per STCR equation to preceding *kharif* groundnut recorded significantly higher energy output, system net energy returns and energy intensiveness than rest of all the treatment combinations. The application of 100 per cent recommended dose of fertilizer to succeeding crops was registered significantly higher system net energy returns, energy output-input ratio and energy intensiveness than rest of the treatment combinations (Table 5). The both crops (groundnut and chickpea) fixes atmospheric nitrogen thereby reduces the input energy required for obtaining higher yield resulting in higher output-input ratio and system net energy returns [1][3].

Economics: Among the cropping systems, groundnut- onion cropping system obtained significantly higher gross (Rs. 283156 / ha) and net monetary returns (Rs.188095/ ha) and B:C ratio (2.98) than groundnut-wheat and groundnut-chickpea cropping systems. The groundnut-chickpea cropping system was found second rank in respect of net monetary returns. Application of fertilizer as per STCR equation to *kharif* groundnut obtained significantly maximum gross(Rs. 241694/ ha) and net monetary returns (Rs. 158071/ ha) and B: C ratio (2.90) than rest of the nutrient management treatments. Application of 100 % RDF to succeeding crop during *rabi* season obtained significantly higher gross (Rs.189476/ ha) and net monetary returns (Rs.109891/ ha) and B:C ratio than 50 % RDF and at par with 75 % RDF in respect of gross and net monetary returns and B: C ratio (Table 4). Thus it can be concluded that, groundnut (*Arachis hypogaea* L.)-onion (*Allium cepa* L) cropping system found to be most efficient and suitable for achieved maximum productivity, energetic and monetary returns with application of fertilizer as per soil test crop response (STCR) equation.

Table 3. Yield of component crops in different cropping systems as influenced by different treatments.

Treatment	Gr.nut pod yield (q/ ha)			Onion bulb yield (t/ ha)			Wheat grain yield (q/ ha)			Chickpea grain yield (q /ha)		
	2011-12	2012-13	Pooled mean	2011-12	2012-13	Pooled mean	2011-12	2012-13	Pooled mean	2011-12	2012-13	Pooled mean
Nutrient management	16.43	17.61	17.11	53.37	55.71	54.54	39.04	39.68	39.36	25.64	26.34	25.99
(N)	18.91	19.59	19.26	54.86	56.52	55.69	40.15	41.49	40.82	26.37	27.43	26.90
T_1 -	23.08	24.49	23.55	58.85	60.67	59.76	42.13	43.11	42.62	28.62	29.28	28.95
Recommended	7.96	6.63	7.30	13.68	13.28	13.48	13.47	12.66	13.07	14.01	13.06	13.53
dose of	0.59	0.52	0.49	0.76	0.82	0.60	0.26	0.38	0.41	0.27	0.59	0.45
fertilizer	1.71	1.54	1.44	2.64	2.83	2.72	0.91	1.33	1.44	0.95	2.05	2.03
T_2 –Fertilizer dose as per soil test												
T_3- Fertilizer dose as per STCR eq^n ($25qha^{-1}$)												
T_4-Control (No fertilizer)												
SEm ±												
C.D. at 5%												
B. Fertilizer levels (F)	--	--	--	48.03	49.75	48.89	35.98	36.82	36.40	26.41	26.49	26.45
F_1-100% of RDF	--	--	--	45.95	47.66	46.80	34.21	35.41	34.81	24.15	24.46	24.30
F_2-75% of RDF	--	--	--	41.60	42.23	41.91	30.91	32.49	31.69	20.43	21.14	20.78
F_3-50% of RDF	--	--	--	0.52	0.68	0.46	0.39	0.46	0.74	0.37	0.36	0.43
SEm ±	--	--	--	2.05	2.65	2.79	1.54	1.79	2.36	1.46	1.42	2.61
C.D. at 5%												

Table 4. Groundnut equivalent yield, protein, carbohydrates and fat yield Land use efficiency, production efficiency and economic efficiency as influenced by different treatments. (Pooled mean of 2 years)

Treatment	Groundnut equivalent yield (t / ha)	Protein yield (t/ha)	Carbohydrate yield (t/ha)	Fat yield (t/ha)	Land utilization indx (%)	Production efficiency (kg / ha/ day)	Economic efficiency (Rs./ ha/ day)
Cropping system							
Groundnut-	7.82	0.74	5.41	0.81	59.84 (218)	35.06	842.46
onion	3.27	0.61	2.79	0.55	58.89 (215)	15.01	209.36
Groundnut-	4.06	0.82	1.59	0.55	57. 24	19.27	363.49
wheat	0.06	0.06	0.67	0.13	(209)	0.15	5.95
Groundnut-	0.19	0.17	1.90	N.S.	--	0.45	17.45
chickpea					--		
SEm ±							
C D (P= 0.05)							
Nutrient							
management	5.61	0.78	3.73	0.65	58.61	25.81	552.35
Recommended	5.93	0.83	3.87	0.73	(214)	27.08	598.16
dose of	6.69	0.95	4.20	0.88	59.16	30.25	713.34
fertilizer	1.97	0.33	1.25	0.29	(216)	9.31	23.24
Fertilizer dose	0.08	0.04	0.78	0.15	59.43	0.18	6.87
as per soil test	0.24	0.13	2.20	0.43	(217)	0.53	20.15
Fertilizer dose					57.52 (210)		
as per STCR eq^{n}					---		
(25 t / ha)					---		
Control (No							
Fertilizers)							
SEm ±							
CD (P= 0.05)							
Fertilizer levels							
100% of RDF	5.24	0.75	3.46	0.62	59.28	24.12	499.77
75% of RDF	5.18	0.74	3.32	0.65	(215)	23.55	492.32
50% of RDF	4.73	0.68	3.01	0.63	59.12	21.67	423.22
SEm ±	0.05	0.03	0.67	0.13	(214)	0.21	3.76
C D (P= 0.05)	0.14	0.10	NS	N.S.	58.06	0.60	10.69
					(212)		

Market price: 2011-12: Groundnut 34500 Rs./t, Onion Rs.3600 /t Wheat Rs.14000 /t, Chickpea Rs.33000/t 2012-13: Groundnut 37500 Rs. /t, Onion 6000 Rs./t, Wheat 18000 Rs./t, Chickpea Rs.36000 /t.

Table 5. Energy indices different cropping systems as influenced by different nutrient managements (Pooled mean of 2 years)

Treatment	Input energy (X10^{3} MJ ha^{-1})	Output energy (X10^{3} MJ ha^{-1})	System net energy returns (X10^{3} MJ ha^{-1})	Energy output-input ratio	Energy balance per unit input	Energy Intensiveness (MJ/`)
Cropping system						
Groundnut-onion	23.57	158.49	134.91	6.72	5.72	1.66
Groundnut-wheat	20.97	183.28	162.31	8.74	7.74	2.54
Groundnut-chickpea	18.18	179.24	161.06	9.54	8.85	2.59
SEm ±	0.12	1.09	1.09	0.05	0.05	0.03
C D (P= 0.05)	0.36	3.21	3.22	0.16	0.16	0.09
Nutrient management						
Recommended dose of	21.01	185.06	164.05	8.81	7.81	2.25
fertilizer	22.31	202.34	180.03	9.06	8.07	2.44
Fertilizer dose as per soil	25.71	233.86	208.14	9.09	8.10	2.81
test	14.59	73.42	58.83	5.03	4.05	1.11
Fertilizer dose as per STCR	0.14	1.26	1.26	0.06	0.06	0.04
eq^{n} (25 t/ha)	0.42	3.71	3.71	0.18	0.18	0.12
Control (No Fertilizers)						
SEm ±						
CD (P= 0.05)						
Fertilizer levels						
100% of RDF	21.97	186.84	166.03	8.50	7.56	2.35
75% of RDF	20.91	172.32	154.83	8.23	7.40	2.19
50% of RDF	19.84	153.68	137.42	7.74	6.92	1.97
SEm ±	0.08	1.09	1.09	0.06	0.06	0.04
C D (P= 0.05)	0.22	3.11	3.12	0.17	0.18	0.12

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