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RESEARCH PAPER

Productivity of different cropping systems as influenced by resource conservation techniques

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Abstract : The field experiment was conducted on loamy sand soils of Agronomy Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar (Gujarat) during the years 2012-13 and 2013-14 to study productivity of different cropping systems as influenced by resource conservation techniques. Cotton - summer pearlmillet cropping system was found significantly superior by recording higher pearlmillet equivalent yield and nutrients profitability, while, water productivity, water profitability and nutrients productivity were found higher under greengram + *Kharif* castor (relay) cropping system. Greengram - mustard - summer pearlmillet recorded the highest agro-energy. Residue incorporation secured top position by recording significantly the highest pearlmillet equivalent yield, water productivity, water profitability, nutrients productivity, nutrients profitability as well as agro-energy. The application of 75 % RDN through inorganic fertilizer + 25 % RDN through FYM recorded significantly the highest pearlmillet equivalent yield, water productivity, water profitability, nutrients productivity, nutrients profitability and agro-energy.

Key Words : Cropping system, Residue incorporation, FYM, Nutrients productivity, Nutrients profitability, Water productivity, Water profitability

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INTRODUCTION

In spite of substantial gain in agriculture production over the past few decades, the task of meeting the food grains, feed, fodder and fuel needs of increasing human and livestock population remains a formidable challenge before scientific community. Though India is a food surplus nation at present with about 231.5 million tonnes food grain production per annum, it will require about 4-5 million tonnes additional food grains every year if the trend in rising population persists (Anonymous, 2010). This additional production has to come from existing land and water resources. The present situation is comfortable, but to meet the future demand, we would need better planning and resource management as well as intensification of crop production.

Suitable cropping systems seem to be the possible solution to meet the continuous increase in demand for food, stability of income and diverse requirement of food

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grains. Addition of different crops provides ways to recycle products and by products of one crop as input through another crop and reduce the cost of production, increase production and thus, increase total income of farm (Ravisankar *et al*., 2007). The cropping systems selected in study have higher potential of production along with incorporable residues during winter. Proper or integrated nutrient management involving conjunctive use of organic, inorganic and crop residues may improve soil productivity (Patra *et al*., 2000 and Kumar *et al*., 2001) and also develop sustainable system productivity (Raju and Reddy, 2000). The residues of cotton, castor and mustard crops have more potential to feed nutrients to soil as compared to burning. So incorporation of such crops residues in to soil helps to recycle the nutrients to correct their deficiencies.

Farmyard manure (FYM) is being used as major source of organic manure in field crops. Thus, to maintain the soil health, integrated nutrient management approaches involving FYM and mineral source need to be standardized. Studies indicated that use of organic sources can help to maintain a better N : P ratio and can produce higher yield (Bakhtiar *et al*., 2002 and Khanam *et al*., 2001). The combined use of organic and chemical fertilizers will help to maintain soil productivity even under intensive cropping systems. Beside crop productivity, nutrients and water productivity as well as profitability are required to be improved by adopting these techniques because nutrients and water are the important factors in today's agriculture. So there is need to find out cropping system which can perform better for increasing productivity and profitability of crops as well as nutrients and water with association of conservation of natural resources.

MATERIAL AND METHODS

The field experiment was conducted on loamy sand soils of Agronomy Instructional Farm, C. P. College of Agriculture, S.D. Agricultural University, Sardarkrushinagar (Gujarat) during the years 2012-13 and 2013-14 to study productivity of different cropping systems as influenced by resource conservation techniques". The soil of the experimental plot was low in organic carbon (0.20 %) and available nitrogen, medium in available phosphorus and potash with particle density of 2.784 g/cc and bulk density of 1.639 g/cc. The experiment was laid out in split plot design with three replications. Sixteen treatment combinations comprising of four cropping system treatments *viz*, C_1 : Cotton- summer pearlmillet, C_2 : Greengram + *Kharif* castor (Relay), C_3 : Greengram - mustard - summer pearlmillet and C_4 : Greengram - *Rabi* castor and two residue incorporation treatments *viz.*, R_0 : No residue incorporation and R_1 : Residue incorporation as well as two fertilizer doses *viz.*, F_1 : 100 % RDN through inorganic fertilizer and F_2 : 75 % RDN through inorganic fertilizer + 25 % RDN through FYM were evaluated in the study. The *ex-situ* cotton, mustard and castor crop's residues were incorporated during second fortnight of May month in respective treatments with the help of rotovator before initiation of experiment for making treatment equity. The quantity of residue (kg/ha) was calculated according to seed and straw ratio of different crops. During the 1st and 2nd year of experimentation *in-situ* cotton and mustard crop's residue incorporation was done in second fortnight of February while castor in second fortnight of May month and field was prepared for sowing of next crop. According to nutrients content (0.5 % N, 0.25 % P_2O_5 and 0.5 % K_2O), the application of FYM for 25 % nitrogen was done in respective treatments before the sowing of each crop. There was no severe attack of insect and pest observed during the entire growth periods of different crops. Pearlmillet crop was considered for equivalent yield because it is predominant crop of the region and it has less fluctuation of price as compared to other crop taken in experiment. The pearlmillet equivalent yield was calculated on the basis of formula given below:

$$\text{PMEY (kg/ha)} = \frac{\text{Yield of pearlmillet crop x} \frac{\text{Price of pearlmillet}}{} + \text{Yield of sequence crop x} \frac{\text{Price of sequence crop}}{}}{\text{Price of pearlmillet grain (Rs./kg)}}$$

Yield of different crops other than pearlmillet was converted in to pearlmillet equivalent yield according to prevailing market price. Nutrients productivity (kg/kg nutrients) was worked out by dividing the pearlmillet equivalent yield with total quantity of NPK applied (Table A). While, nutrients profitability (Rs./kg nutrients) was calculated by dividing the net returns with total quantity of NPK applied. Same procedure was adopted for calculating water productivity and profitability, total water applied is used in formula instead of total NPK applied (Table A).

Agro-energy was calculated by using following formula:

$$\text{Agro} - \text{energy (Kcal x 1000)} = \frac{\text{Yield (kg/ ha) x Kcl per 1000 g}}{1000}$$

Table A: Number of irrigation, total water and total nutrients (N, P_2O_5, K_2O and S kg/ha) applied in particular crop as well as in sequence

Treatment symbols	Number of irrigations				Water applied (mm)	Total nutrients (N, P_2O_5, K_2O and S) applied (kg/ha)			
	K	R	S	Total		K	R	S	Total
$C_1R_0F_1$	10	-	7	17	850	260.0	-	180.0	440.0
$C_1R_0F_2$	10	-	7	17	850	260.0	-	180.0	440.0
$C_1R_1F_1$	10	-	7	17	850	260.0	-	180.0	440.0
$C_1R_1F_2$	10	-	7	17	850	260.0	-	180.0	440.0
$C_2R_0F_1$	10	-	-	10	500	297.5	-	-	297.5
$C_2R_0F_2$	10	-	-	10	500	297.5	-	-	297.5
$C_2R_1F_1$	10	-	-	10	500	297.5	-	-	297.5
$C_2R_1F_2$	10	-	-	10	500	297.5	-	-	297.5
$C_3R_0F_1$	1	6	7	14	700	60.0	165	180.0	405.0
$C_3R_0F_2$	1	6	7	14	700	60.0	165	180.0	405.0
$C_3R_1F_1$	1	6	7	14	700	60.0	165	180.0	405.0
$C_3R_1F_2$	1	6	7	14	700	60.0	165	180.0	405.0
$C_4R_0F_1$	1	9	-	10	500	60.0	237.5	-	297.5
$C_4R_0F_2$	1	9	-	10	500	60.0	237.5	-	297.5
$C_4R_1F_1$	1	9	-	10	500	60.0	237.5	-	297.5
$C_4R_1F_2$	1	9	-	10	500	60.0	237.5	-	297.5

K= Kharif, R=Rabi and S=Summer

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Performance of cropping systems:

Prevailing market price become an additional important factor in choosing the components of cropping systems and so sequence crop yields were converted into pearlmillet equivalent yield (Table 1 and Fig. 1). Pearlmillet equivalent yield was significantly higher (15,241 kg/ha) with cotton - summer pearlmillet cropping system than rest of the treatments but it remained at par with greengram - mustard - summer pearlmillet. The magnitude of increase in pearlmillet equivalent yield in cotton - summer pearlmillet cropping system was to the tune of 8 per cent, 44 per cent and 57 per cent over greengram - mustard - summer pearlmillet, greengram + *Kharif* castor (relay) and greengram - *Rabi* castor, respectively. Higher pearlmillet equivalent yield secured in cotton - summer pearlmillet cropping system might be due to higher biomass production of cotton crop during *Kharif* as well as summer pearlmillet gave higher yields when it is grown after cotton in sequence. These finding are in conformity with those reported by SDAU (2010) and SDAU (2011). They reported that cotton - summer pearlmillet was remunerative cropping system as compared to others.

With the erratic distribution and amount of precipitation resultant effect as climate change, there is a need to establish and develop such cropping systems which have ability to adjust against the changing pattern of climate and weather parameters. In the above scenario, a cropping system that produce substantial yield *vis-à-vis* the amount of irrigation water applied taking into consideration the economics of the total yield will fulfill the farmers requirement.

The different water requirement of the various crops (Table A) and the equivalent yield produced depicts the water productivity of the system. Greengram + *Kharif* castor (relay) cropping system secured significantly the highest water productivity of 21.18 kg/ha mm. The magnitude of increase in water productivity in greengram + *Kharif* castor (relay) cropping system was to the tune of 5 per cent, 9 per cent and 18 per cent as compared to greengram - mustard - summer pearlmillet, greengram - *Rabi* castor and cotton - summer pearlmillet. Higher water productivity obtained in treatment due to lower amount of irrigation water applied to greengram and *Kharif* castor (relay) sequence which gave higher yield. These findings are in close conformity with those reported by SDAU (2010) and SDAU (2011).

The water requirement of the various crops and net monetary return depicts the water profitability of the system. Significantly the highest water profitability (Rs. 183/ha mm) was obtained from greengram + *Kharif* castor (relay) cropping system which indicates that this cropping system offered the potential of achieving profitable water utilization with production. Higher value of water profitability in this treatment was recorded because short duration greengram crop required little water and on the other hand castor is basically dryland plant grown in irrigated conditions responded extremely well and resulted in higher production with less amount of water. These findings corroborate with those reported by SDAU (2010) and SDAU (2011).

Nutrients are the major factor for obtaining optimum yield in cropping system. The main objective in cropping system is to increase the total yield from per unit of nutrients applied which depicts nutrients productivity (Table 1). Cropping system greengram + *Kharif* castor (relay) was found significantly superior by recording higher nutrient productivity (35.59 kg/kg nutrients). Greengram + *Kharif* castor (relay) cropping system

Table 1: Pearl millet equivalent yield, water productivity and profitability, nutrients productivity and profitability as well agro-energy as influenced by different treatments (Pooled of 2012-13 and 2013-14)

Treatments	Pearlmillet equivalent yield (kg/ha)	Water productivity (kg/ha mm)	Water profitability (Rs./ha mm)	Nutrients productivity (kg/kg nutrients)	Nutrients profitability (Rs./kg nutrients)	Agro-energy (Kcal x 1000)
Cropping systems						
C_1 : Cotton - Summer pearl millet	15,241	17.93	163	34.64	316	23,462
C_2 : Greengram + *Kharif* castor (Relay)	10,589	21.18	183	35.59	308	2,512
C_3 : Greengram - Mustard - Summer pearl millet	14,096	20.14	166	34.80	288	27,238
C_4 : Greengram - *Rabi* castor	9,701	19.40	153	32.61	257	3,395
S.E.±	170	0.27	3.75	0.47	6.59	45
C. D. (P=0.05)	523	0.83	11.55	1.45	20.31	138
C. V. %	8.84	9.40	15.20	9.32	15.05	1.75
Residue incorporation						
R_0 : No residue incorporation	11,507	18.21	148	31.88	259	13,107
R_1 : Residue incorporation	13,306	21.11	185	36.94	325	15,197
S.E.±	85	0.13	1.83	0.23	3.22	40
C. D. (P=0.05)	238	0.37	5.14	0.65	9.05	112
Fertilizer doses						
F_1 : 100 % RDN through inorganic fertilizer	11,990	18.99	162	33.23	285	13,634
F_2 : 75 % RDN through inorganic fertilizer + 25 % RDN through FYM	12,824	20.34	171	35.59	299	14,669
S.E.±	69	0.11	1.49	0.19	2.63	33
C. D. (P=0.05)	194	0.30	4.20	0.53	7.39	92
C. V. %	4.41	4.58	7.42	4.55	7.35	1.56
Interaction						
C x R	NS	NS	NS	NS	NS	Sig.
C x F	NS	NS	NS	NS	NS	Sig.
R x F	NS	NS	NS	NS	NS	NS
C x R x F	NS	NS	NS	NS	NS	NS

Selling price (Rs./kg) : Cotton : 45, Cotton stalk : 0.5, Greengram seed : 41, Greengram straw : 2.5, Castor seed: 35, Castor stalk : 0.5, Mustard seed: 35, Mustard stalk : 0.5, Pearlmillet grain : 14, Pearlmillet straw : 3

* Energy in different crops in 100 g according to Narasinga Rao *et al.* (2009)

Cotton : 332 g, Greengram : 334 g, Mustard : 541 g, Pearl millet : 361 g NS= Non-significant

secured 2 per cent, 3 per cent and 9 per cent higher nutrient productivity as compared to greengram - mustard - summer pearlmillet, cotton – summer pearlmillet and greengram - *Rabi* castor. Higher nutrients productivity obtained in this treatment due to higher yield with higher nutrient consumption capacity of these crops even though less nutrients applied in sequence. Per kg nutrient applied in greengram + *Kharif* castor (relay) cropping system gave higher yield. Similar observation was earlier made by SDAU (2010) and SDAU (2011).

Nutrients profitability is a function of overall net profit obtained from per kg nutrients applied (Table 1). The nutrient profitability (Rs. 316/kg nutrients) among cropping systems was higher in cotton - summer pearlmillet being at par with greengram + *Kharif* castor (relay) cropping system. Higher nutrient profitability secured in this treatment because cotton - summer pearlmillet is remunerative cropping system which gave higher yield resulted in higher amount of net return which helped to increase profitability per kg nutrients applied. The same trend revealing this cropping system as more paying practice from per kg nutrients than other cropping systems was reported by SDAU (2010) and SDAU (2013).

Table 1 indicated that agro-energy (27,238 Kcal x 1000) among cropping systems was the highest in greengram - mustard - summer pearlmillet. The magnitude of increase in agro-energy in greengram - mustard - summer pearlmillet system was to the tune of 16 per cent, 702 per cent and 984 per cent as compared to cotton - summer pearlmillet, greengram - *Rabi* castor and greengram - *Kharif* castor. Higher agro-energy in this treatment was due to higher edible yield produced in the system as agro-energy can be calculated on basis of edible part of crop. The findings are in close conformity with those reported by SDAU (2010) and SDAU (2011).

Effect of residue incorpotation:

Pearlmillet equivalent yield was significantly affected by residue incorporation treatments (Table 1 and Fig. 1). Among the treatments tried in experiment, the highest pearlmillet equivalent yield (13,306 kg/ha) was observed under residue incorporation which was 16 per cent higher over no residue incorporation. Higher pearlmillet equivalent yield secured in treatment might be due to residue incorporation increased organic matter in soil and availability of nutrients to crops which resulted higher biomass production. These findings are in conformity with those reported by Kaleeswari *et al.* (2007); Singh *et al*. (2010) and SDAU (2011). Kaleeswari *et al.* (2007) observed that incorporation of crop residue in soil recorded higher grain yield of maize and maize grain equivalent yield. Singh *et al.* (2010) reported that incorporation of crop residues has improved the mean rice equivalent yields of system by 7.86 per cent as compared to their removal. SDAU (2011) observed that residue incorporation significantly increased pearlmillet equivalent yield.

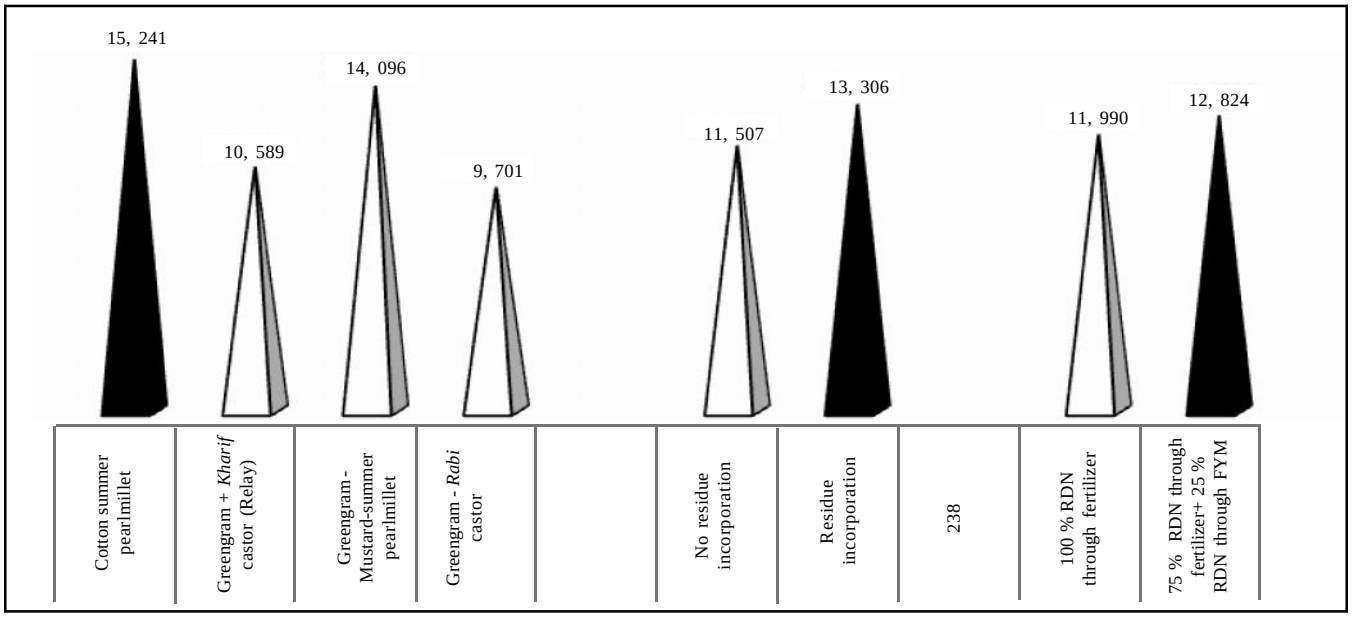

Fig. 1 : Pearlmillet equivalent yield (kg/ ha) in pooled data (2012-13 and 2013-14)

Residues incorporation secured significantly the highest water productivity of 21.11 kg/ha mm. The magnitude of increase in water productivity in this treatment was to the tune of 16 per cent as no residues incorporation. Higher water productivity recorded in the treatment due to higher amount of yield produced from same amount of irrigation water as applied in no residues incorporation. These findings corroborate with those reported by Saha *et al*. (2010). They reported that maximum water-use efficiency was obtained in conventional tillage with residue incorporation, mainly because of maximum yield in maize and mustard obtained under the treatment.

Significantly the highest water profitability (Rs.185/ ha mm) was obtained when residues was incorporated. The magnitude of increase in water profitability in this treatment was to the tune of 26 per cent as no residues incorporation. Higher profitability in this treatment was due to higher amount of net return was obtained from the same amount of water as applied in no residues incorporation.

Data (Table 1) indicated that nutrient productivity (36.94 kg/kg) was found significantly the highest when residue was incorporated in to the soil. Higher nutrients productivity obtained in this treatment due to higher yield from per kg of nutrient applied. Beside this, residues incorporation optimized the C : N ratio and increased micro-organism activity which improve soil health. Soil micro-organisms are responsible for conversion of nutrients in available form. Per kg nutrient yield was higher in residues incorporation treatment.

Nutrients profitability is a function of overall net profit obtained from per kg nutrients applied. Table 1 indicates that nutrient profitability (Rs. 325/kg) was found the highest with incorporation of residues. Higher nutrient profitability secured in this treatment due to higher yield observed in treatment resulted in higher amount of net return which helped to increase profitability per kg nutrients applied. The same trend revealing this treatment as more paying practice per kg nutrients was reported by SDAU (2011) and SDAU (2013).

Agro-energy (15,197 Kcal x 1000) among treatments was the highest in residues incorporation. The magnitude of increase in agro-energy under this treatment was to the tune of 16 per cent as compared to no residues incorporation. Higher agro-energy in this treatment was might be due to higher edible yield produced in the treatment as agro-energy can be calculated on basis of edible part of crop.

Effect of fertilizer dose:

Among the treatments, the highest pearlmillet equivalent yield (12,824 kg/ha) was observed under 75 % RDN through inorganic fertilizer + 25 % RDN through FYM which was 7 % higher over 100 % RDN through inorganic fertilizer (Table 1 and Fig. 1). Higher pearlmillet equivalent yield secured in this treatment might be due to application of FYM which increased organic matter in soil and availability of nutrients to crops which resulted higher biomass production. These finding are in conformity with those reported by Kaleeswari *et al*. (2007); Patil *et al*. (2007) and Jat *et al*. (2011). Patil *et al*. (2007) recorded that application of all recommended package of practice (½ N through urea + ½ N through FYM) registered significantly higher maize equivalent yield as compared to farmers practice and farmers practice except fertilizer + RDF. Jat *et al*. (2011) found that application of FYM 5 t/ha + 50 % RDF to groundnut recorded significantly higher groundnut equivalent yield.

Application of 75% RDN through inorganic fertilizer + 25% RDN through FYM secured significantly the highest water productivity of 20.34 kg/ha mm. The magnitude of increase in water productivity in this treatment was to the tune of 7% over 100% RDN through inorganic fertilizer. Higher water productivity in this treatment due to higher yield obtained in this treatment from the equal amount of water applied in the treatment of 100% RDN through inorganic fertilizer.

Significantly the highest water profitability (Rs.171/ ha mm) was obtained with application of 75 % RDN

Table 2 : Interaction effect of C x R and C x F on agro energy (Pooled of 2012-13 and 2013-14)

Treatments	C_1	C_2	C_3	C_4	Treatments	C_1	C_2	C_3	C_4
R_0	21573	2248	25524	3081	F_1	22610	2394	26321	3212
R_1	25351	2776	28952	3708	F_2	24313	2630	28155	3577
S.E. ±			69.3		S.E. ±			56.59	
C. D. (P=0.05)			194.7		C. D. (P=0.05)			158.99	
C. V. %			1.56		C. V. %			1.56	

through inorganic fertilizer + 25 % RDN through FYM. Higher water profitability in this treatment was due to higher net return obtained in this treatment from the same amount of water applied in 100 % RDN through inorganic fertilizer.

From the data prescribed in Table 1 indicated that nutrient productivity (35.59 kg/kg nutrients) was found significantly the highest with application of 75 % RDN through inorganic fertilizer + 25 % RDN through FYM. Higher nutrients productivity obtained in this treatment mainly due to higher yield observed from same quantity of nutrient applied in 100 % RDN through inorganic fertilizer. Beside this, FYM increased micro-organism activity in soil which improves soil health. Soil micro-organisms are responsible for conversion of nutrients in available form which increased yield of crops. These findings are in agreement with those of Singh and Ahlawat (2012). They reported that substitution of 25% RDN through FYM recorded greater N-use efficiency over 50% RDN substitution through FYM and control.

Nutrients profitability is a function of overall net profit obtained from per kg nutrients applied. Nutrient profitability was found the highest with application of 75 % RDN through inorganic fertilizer + 25 % RDN through FYM (Rs.299/kg nutrients). Higher nutrient profitability secured in this treatment due to higher yield observed in treatment resulted in higher amount of net return which helped to increase profitability per kg nutrients applied.

The agro-energy (14,669 Kcal x 1000) among treatments was the highest in 75 % RDN through inorganic fertilizer + 25 % RDN through FYM. The magnitude of increase in agro-energy in this treatment was to the tune of 8 % as compared to 100 % RDN through inorganic fertilizer. Higher agro-energy in this treatment was due to higher edible yield produced in this treatment as agro-energy can be calculated on basis of edible part of crop.

Interaction effect:

Interaction effect of cropping systems and residue incorporation (C x R) and cropping systems and fertilizer dose (C x F) were found to be significant with respect to agro-energy.

Treatment combination C_3R_1 (greengram - mustard - summer pearlmillet + residue incorporation) recorded significantly the highest agro-energy (28952 Kcal x 1000).

The data on interaction effect of cropping systems and fertilizer dose (C x F) are presented in Table 2 indicate that treatment combination C_3F_2 (Greengram - mustard - summer pearlmillet + 75 % RDN through inorganic fertilizer + 25 % RDN through FYM) recorded significantly the highest agro-energy which was 28,155 Kcal x 1000. The higher agro-energy in both the combination (C_3R_1 and C_3F_2) was due to higher edible yield which resulted due to residue incorporation and FYM. As this cropping system acquired all three crops as edible grain crop that's why this treatment interacted with R_1 (Residue incorporation) and F_2 (75 % RDN through inorganic fertilizer + 25 % RDN through FYM) and gave higher yield.

REFERENCES

Anonymous (2010). Monthly review of the Indian economy (CMIE) August, 2010, Economic Intelligence Service.

Bakhtiar, S.M., Alam, M.J., Mahmood, K. and Rahman, M.H. (2002). Integrated nutrient management under three agro-ecological zones of Bangladesh. *Pakistan J. Biological Sci.*, **5**: 390-393.

Jat, R.S., Dyal, D., Meena, H.N., Singh, V. and Gedia, M.V. (2011). Long term effect of nutrient management and rainfall on pod yield of groundnut (*Arachis hypogaea*) in groundnut based cropping system. *Indian J. Agron.*, **56**(2):145-149.

Kaleeswari, R.K., Kalpana, R. and Devasenapath, P. (2007). Impact of organic resources on soil carbon conservation in maize based cropping system. *J. Farm. Syst. Res. & Develop.*, **13**(1): 122-123.

Khanam, M., Rahman, M.M. and Islam, M.R. (2001). Effect of manures and fertilizers on the growth and yield of BRRI Dhan 30. *Pakistan J. Biological Sci.*, **4** : 172-174.

Kumar, N., Verma, L.P., Singh, R. and Prasad, K. (2001). Soil properties, nutrient uptake and productivity of rice under integrated nutrient management system. *Annl. Plant & Soil Res.*, **3**(1): 54-57.

Narasinga Rao, B. S., Deosthale, Y.G. and Pant, K.C. (2009). *Nutritive value of Indian food.* National Institute of Nutrition, ICMR, Hyderabad. pp. 47-58.

Patil, Y.J., Hile, R.B., Bodake, P.S. and Chauhan, M.R. (2007). Agronomic management for maximizing productivity of maize - wheat cropping system. *J.Farm. Syst. Res.& Develop.*, **13**(1): 122-123.

Patra, A.K., Nayak, B.C. and Mishra, M.M. (2000). Integrated nutrient management in rice-wheat cropping system. *Indian J. Agron.*, **45**(3): 453-457.

Raju, R.A. and Reddy, M.N. (2000). Sustainability and

productivity in rice - rice sequential cropping systems through integrated nutrient management in costal eco system. *Indian J. Agron.*, **45**(3): 447-452.

Ravisankar, N., Pramanik, S.C., Jayakumar, S., Singh, D.R., Bibi, N., Nawaz, S. and Biswas, T.K. (2007). Study on integrated farming system (IFS) under different resource conditions of island ecosystems. *J. Farm. Syst. Res. & Develop.*, **13**(1): 1-9.

SDAU (2010). Annual report, AICRP on IFS, SDAU. pp. 24-31, 64-70.

SDAU (2011). Annual report, AICRP on IFS, SDAU. pp. 24-32, 64-70.

SDAU (2013). 10th AGRESCO Report, AICRP on IFS, pp. 28-33.

Singh, S.K., Kumar, D. and Lal, S.S. (2010). Integrated use of crop residues and fertilizers for sustainability of potato (*Solanum tuberosum*) based cropping systems in Bihar. *Indian J. Agron.*, **55**(3): 203-208.

Saha, S., Chakraborty, D., Sharma, A.R., Tomar, R.K., Bhadraray, S., Sen, U., Behera, U.K., Purakayastha, T.J., Garg, R.N. and Kalra, N. (2010). Effect of tillage and residue management on soil physical properties and crop productivity in maize (*Zea mays*)–Indian mustard (*Brassica juncea*) system. *Indian J.Agric. Sci.*, **80**(8): 679–685.

Singh, R.J. and Ahlawat, I.P.S. (2012). Dry matter, nitrogen, phosphorous and potassium partitioning, accumulation and use efficiency in transgenic cotton-based cropping systems. *Communi. Soil Sci.& Plant Anal.*, **43**(20): 2633-2650.