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National Academy of Agricultural Science (NAAS) Rating : 3. 03

Economics and Energetics of Rice as Influenced by Pelleted Integrated Nutrient Management under Transplanted Ecosystem

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ABSTRACT: *A field experiment was conducted in* kharif-2012 *at Instructional-cum-Research Farm at Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh) to investigate effect of integrated nutrient management by pelleting techniques to increase growth, yield and nutrient use efficiency in transplanted rice. The pelleted 2.5t FYM +80:50:30 kg N: P_2O_5:K_2O ha^{-1} produced highest grain yield, straw yield and harvest index. The treatment received pelleted 2.5t FYM + 80:50:30 kg N: P_2O_5:K_2O ha^{-1} gave the highest B: C ratio (2.06), gross returns and net returns. The net gain energy was found maximum in pelleted 2.5t FYM + 80:50:30 kg N: P_2O_5:K_2O ha^{-1} while highest grain production efficiency was observed under control treatment followed by pelleted 5t FYM + 50:30:20 kg N: P_2O_5:K_2O ha^{-1}.*

Key words: *pelleting techniques, B: C ratio, net returns, energetics, grain production efficiency*

INTRODUCTION

Rice (*Oryza sativa* L.) is the world's most important crop and the primary source of food for more than half of the world's population. Rice accounts for 35 to 75% of the calories consumed by more than 3 billion Asians and is planted to about 154 million hectare annually or on about 11% of the total world's cultivated land. India is second largest producer after China and has an area of over 45.5 million hectares (Gujja and Thiyagarajan, 2012) and production 105.31 million tonnes with productivity 2393 kg ha^{-1} (Anonymus, 2013). The rice culture system in Chhattisgarh mainly depends on the onset and distribution of monsoonal rains. They can be broadly classified into three categories namely rice growing on upland situation mostly rainfed, medium land rice both in direct dry seeded broadcast "*Biasi*" and transplanting under protective irrigated conditions or both. In transplanting method, generally field is puddle before transplanting and kept submerged. The submerged rice fields brings a series of physical, chemical and microbiological changes in the soil, which profoundly affects growth of rice plant as well as availability, loss and absorption of nutrients. The role of plant nutrients would be extremely important from sustainability point of view. With the increasing trend in use of chemical fertilizers, growing ecological concerns, conservation of energy and reduction in the use of organic manures have created considerable interest for the use of organics as a source of plant nutrients with blending of chemical fertilizer as an integrated nutrient management system. Therefore, information needs to be generated with respect to proper dose of organic manures along with inorganic fertilizers, to develop the suitable nutrient management practices for better quality and productivity of rice and to increase nutrient use efficiency. Pellets are nutrient rich source and can be served as a substitute to cut down the cost of fertilizers and organic manures input and to increase the productivity in addition to maintain soil productivity, improve the eco-system and ultimately resulting in improved soil-plant-health in a sustainable agricultural eco-system. The densification process and pellet production is able to convert manure into a compressed form with advantages in transportation, handling and storage (Bhattacharya *et al.*, 1989) and adjusting the nutrient content by adding chemical fertilizers. The small mass of pellet contains all essential major nutrients and micronutrients and releases these

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nutrients slowly in root zones, making available for long times and reducing their losses in different forms.

MATERIAL AND METHODS

The experiment was conducted during *kharif*-2012, at Instructional-cum-Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh) India. The experimental site lies between 21°16′N latitude and 81°26′E longitude with an altitude of 289.56 meters above the mean sea level. The soil of experimental farm was neutral in pH (7.65), low in nitrogen (201 kg ha^{-1}), medium in phosphorus (19.6 kg ha^{-1}) and high in potassium (282 kg ha^{-1}). The test variety used was MTU 1010 and experiment was carried out in RBD design with thirteen treatments in three replications. The treatments were T_1 : Conventional 100:60:40 kg N: P_2O_5:K_2O ha^{-1}, T_2 : Conventional 2.5t FYM + 80:50:30 kg N: P_2O_5:K_2O ha^{-1}, T_3 : Conventional 2.5t FYM + 60:40:20 kg N: P_2O_5: K_2O ha^{-1}, T_4 : Conventional 5t FYM + 50:30:20 kg N: P_2O_5: K_2O ha^{-1}, T_5 : Conventional 1t PM + 50:30:20 kg N: P_2O_5: K_2O ha^{-1}, T_6 : Conventional 2.5t FYM + 0.5t PM + 50:30:20 kg N: P_2O_5:K_2O ha^{-1}, T_7 : Pelleted 100:60:40 kg N: P_2O_5: K_2O ha^{-1}, T_8 : Pelleted 2.5t FYM + 80:50:30 kg N: P_2O_5: K_2O ha^{-1}, T_9 : Pelleted 2.5t FYM + 60:40:20 kg N: P_2O_5: K_2O ha^{-1}, T_{10} : Pelleted 5t FYM + 50:30:20 kg N: P_2O_5: K_2O ha^{-1}, T_{11} : Pelleted 1t PM + 50:30:20 kg N: P_2O_5: K_2O ha^{-1}, T_{12} : Pelleted 2.5t FYM + 0.5t PM+50:30:20 kg N: P_2O_5: K_2O ha^{-1} and T_{13} : Control. The nutrients were supplied with fertilizers- urea, DAP, SSP and MOP and organic manures- FYM and poultry manure in different combinations as per the treatments. The nitrogen application was splitted into three parts, one third nitrogen was applied as basal and rest were applied at tillering and panicle initiation stages, while full dose of phosphorus and potassium were given as basal dose. The fertilizers and manures were broadcasted in conventional treatments while placed in pelleted form in pelleted treatments. The observations were recorded at fifteen days interval after 15 DAT-60 DAT and at harvest for growth parameters and after harvest the yield was recorded separately and computed by the help of statistical analysis.

Cost of cultivation for each treatment was calculated separately. Gross return (Rs. ha^{-1}) was obtained by converting the harvest into monetary terms of the prevailing market rate during the course of studies for every treatment. Net return was obtained by deducting cost of cultivation from gross return. The benefit: cost ratio was calculated with the help of following formula:

$$Benefit:cost\ ratio = \frac{Net\ return\ (Rs.ha^{-1})}{Total\ cost\ of\ cultivation\ (Rs.ha^{-1})}$$

Energy inputs were calculated and estimated in Mega Joule (MJ) ha^{-1} with reference to the standard values prescribed by Mittal *et al*. (1985). The standard energy coefficient for seed and straw of rice was multiplied with their respective yields and summed up to obtain the total energy output. The energy input for rice was calculated by adding the respective values under rice crops. Grain production efficiency, energy output–input ratio, was calculated as per the following formula:

$$Grain\ production\ efficienty\ (q\ MJ^{-1} \times 10^{-3}) = \frac{Total\ produce\ (q)}{Energy\ input\ (MJ \times 10^{-3})}$$

$$Energy\ output\ input\ ratio = \frac{Energy\ output}{Energy\ input}$$

RESULT AND DISCUSSION

Effect of pelleted integrated nutrient management on growth parameters: Among the conventional and pelleted treatments, highest plant height (fig 1) was recorded under pelleted 2.5t FYM + 80:50:30 kg N: P_2O_5: K_2O ha^{-1} (T_8) at all stages, except at 15 DAT. At 15 DAT, the treatment conventional 100:60:40 kg N: P_2O_5: K_2O ha^{-1} (T_1) produced highest plant height. However, control treatment recorded lowest plant height at all the stages of crop growth. The observations revealed that after 15 DAT to crop harvest, pelleted 2.5t FYM + 80:50:30 kg N: P_2O_5: K_2O ha^{-1} (T_8) produced highest number of tillers $hill^{-1}$, while control treatment produced lowest number of tillers $hill^{-1}$. The highest leaf area index was noticed under pelleted 2.5t FYM + 80:50:30 kg N: P_2O_5: K_2O ha^{-1} (T_8) treatment from 30 DAT to harvesting, while at 15 DAT, conventional 100:60:40 kg N: P_2O_5:K_2O ha^{-1} produced highest leaf area index. The control treatment produced lowest leaf area index at all intervals of crop growth. The highest dry matter accumulation recorded under conventional 100:60:40 kg N: P_2O_5: K_2O ha^{-1} (T_1) at 15 DAT thereafter pelleted 2.5t FYM + 80:50:30 kg N: P_2O_5: K_2O ha^{-1} (T_8) produced highest dry matter accumulation. The control treatment produced least dry matter accumulation at all stages of crop growth.

Effect on grain and straw yield: The pelleted 2.5t FYM + 80:50:30 kg N: P_2O_5: K_2O ha^{-1} (T_8) produced the significantly highest grain yield (Fig 2), which was at par to that pelleted 100:60:40 kg N: P_2O_5: K_2O ha^{-1}

(T_7) and pelleted 5t FYM + 50:30:20 kg N: P_2O_5: K_2O ha^{-1} (T_{10}). The increase in grain yield was mainly associated with significant increase in effective tillers $hill^{-1}$, filled spikelets $hill^{-1}$ and test weight. The higher grain yield may be due to the application of organic source of nutrients in combination with inorganic sources of nutrients, resulted in greater availability of essential nutrients to plant, improvement to soil environment which facilitated in better root proliferation leading to higher absorption of water and nutrients and their translocation from source to sink (Ebaid *et al*., 2007), ultimately resulting in higher yield. The blending of nitrogen with FYM helps in continuous supply of the nutrients, reduced nutrients loss and enhanced nutrient use efficiency and yield as reported by Pandey and Nandeha (2004), Sarawgi and Sarawgi (2004) and Jha *et al.* (2006). The treatment, pelleted 2.5t FYM+ 80:50:30 kg N:P_2O_5:K_2O ha^{-1} (T_8) produced significantly higher straw yield as compared to others, however, it was comparable to that obtained under treatment pelleted 100:60:40 kg N:P_2O_5:K_2O ha^{-1} (T_7), pelleted 2.5t FYM + 60:40:20 kg N:P_2O_5:K_2O ha^{-1} (T_9), pelleted 5t FYM + 50:30:20 kg N:P_2O_5:K_2O ha^{-1} (T_{10}), pelleted 2.5t FYM + 0.5t PM + 50:30:20 kg N:P_2O_5:K_2O ha^{-1} (T_{12}), conventional 2.5t FYM + 80:50:30 kg N:P_2O_5:K_2O ha^{-1} (T_2) and conventional 100:60:40 kg N:P_2O_5:K_2O ha^{-1} (T_1). The treatment pelleted 2.5t FYM + 80:50:30 kg N:P_2O_5:K_2O ha^{-1} (T_8) recorded significantly higher harvest index than control treatment (T_{13}), which recorded lowest harvest index, all the treatments were found to similar to the highest performing harvest index treatment. Rizwan *et al*. (2003) found that harvest index is less sensitive to N fertilizer timing and splitting.

Economics: Effect of different treatments cannot be assessed without the gross and net profit from that treatment. The economics of conventional and pelleted integrated nutrient management treatments have been presented in Table 1. Among the conventional and pelleted integrated nutrient management, the maximum input cost was involved under the treatment of pelleted 100:60:40 kg N:P_2O_5:K_2O ha^{-1} (T_7) followed by pelleted 2.5t FYM + 80:50:30 kg N:P_2O_5:K_2O ha^{-1} (T_8), conventional 100:60:40 kg N:P_2O_5:K_2O ha^{-1} (T_1) and conventional 2.5t FYM + 80:50:30 kg N:P_2O_5:K_2O ha^{-1} (T_2). The pelleted 80:50:30 kg N:P_2O_5:K_2O ha^{-1} (T_8) resulted in highest gross return (Rs. 77505.00 ha^{-1}) followed by pelleted 100:60:40 kg N:P_2O_5:K_2O ha^{-1} (T_7) (Rs. 69465.00 ha^{-1}), pelleted 5t FYM + 50:30:20 kg N:P_2O_5:K_2O ha^{-1} (T_{10}) (Rs. 68755.00 ha^{-1}) and conventional 2.5t FYM + 80:50:30 kg N:P_2O_5:K_2O ha^{-1} (T_2) (Rs. 66655.00 ha^{-1}). The highest net return (Rs.52157.28 ha^{-1}) was recorded under pelleted 2.5t FYM + 80:50:30 kg N:P_2O_5:K_2O ha^{-1} (T_8) followed by pelleted 100:60:40 kg N:P_2O_5:K_2O ha^{-1} (T_7) (Rs. 44095.28 ha^{-1})), pelleted 5t FYM + 50:30:20 kg N:P_2O_5:K_2O ha^{-1} (T_{10}) (Rs. 43836.88 ha^{-1}) and conventional 2.5t FYM + 80:50:30 kg N:P_2O_5:K_2O ha^{-1}

Table 1
Economics of rice as influenced by conventional and pelleted integrated nutrient management

	Treatment	*Fixed cost (Rs. ha^{-1})*	*Variable cost (Rs. ha^{-1})*	*Total cost (Rs. ha^{-1})*	*Gross return (Rs. ha^{-1})*	*Net return (Rs. ha^{-1})*	*B:C ratio*
T_1	Conventional 100:60:40 kg N: P_2O_5:K_2O ha^{-1}	20647.00	4422.72	25069.72	65960.00	40890.28	1.63
T_2	Conventional 2.5t FYM + 80:50:30 kg N: P_2O_5: K_2O ha^{-1}	20647.00	4400.72	25047.72	66655.00	41607.28	1.66
T_3	Conventional 2.5t FYM + 60:40:20 kg N: P_2O_5: K_2O ha^{-1}	20647.00	3628.83	24275.83	60560.00	36284.17	1.49
T_4	Conventional 5t FYM + 50:30:20 kg N: P_2O_5: K_2O ha^{-1}	20647.00	3971.12	24618.12	63320.00	38701.88	1.57
T_5	Conventional 1t PM + 50:30:20 kg N: P_2O_5: K_2O ha^{-1}	20647.00	2921.12	23568.12	58650.00	35081.88	1.49
T_6	Conventional 2.5t FYM + 0.5t PM + 50:30:20 kg N: P_2O_5:K_2O ha^{-1}	20647.00	3446.12	24093.12	61650.00	37557.88	1.56
T_7	Pelleted 100:60:40 kg N: P_2O_5:K_2O ha^{-1}	20647.00	4722.72	25369.72	69465.00	44095.28	1.74
T_8	Pelleted 2.5t FYM + 80:50:30 kg N: P_2O_5:K_2O ha^{-1}	20647.00	4700.72	25347.72	77505.00	52157.28	2.06
T_9	Pelleted 2.5t FYM + 60:40:20 kg N: P_2O_5:K_2O ha^{-1}	20647.00	3928.83	24575.83	67170.00	42594.17	1.73
T_{10}	Pelleted 5t FYM + 50:30:20 kg N: P_2O_5:K_2O ha^{-1}	20647.00	4271.12	24918.12	68755.00	43836.88	1.76
T_{11}	Pelleted 1t PM + 50:30:20 kg N: P_2O_5:K_2O ha^{-1}	20647.00	3221.12	23868.12	60875.00	37006.88	1.55
T_{12}	Pelleted 2.5t FYM + 0.5t PM+50:30:20 kg N: P_2O_5:K_2O ha^{-1}	20647.00	3746.12	24393.12	63910.00	39516.88	1.62
T_{13}	Control	20647.00	520.00	21167.00	36050.00	14883.00	0.70

Table 2
Energetic of rice as influenced by conventional and pelleted integrated nutrient management practices

Treatment	*Energy input (MJ X 10^{-3})*	*Energy output (MJ X 10^{-3})*		*Net gain energy (MJ X 10^{-3})*	*Energy output-input ratio*		*Grain production efficiency (Q.MJ X 10^{-3})*
		Grain	*Straw*		*Grain*	*Straw*	
T_1	9.70	69.97	80.75	150.72	7.21	8.32	4.91
T_2	9.17	70.71	81.63	152.32	7.71	8.90	5.25
T_3	7.89	64.09	75.75	139.84	8.12	9.60	5.53
T_4	8.03	67.33	75.87	143.21	8.38	9.45	5.70
T_5	7.63	62.03	73.75	135.78	8.13	9.67	5.53
T_6	7.83	64.97	80.00	144.97	8.30	10.20	5.64
T_7	9.73	73.65	85.50	159.15	7.57	8.79	5.15
T_8	9.20	82.76	89.13	171.88	9.00	9.69	6.12
T_9	7.93	68.50	80.25	148.75	8.64	10.10	5.88
T_{10}	8.06	73.06	82.87	155.93	9.06	10.30	6.17
T_{11}	7.66	64.53	75.00	139.53	8.42	9.79	5.73
T_{12}	7.87	67.62	80.13	147.75	8.59	10.20	5.84
T_{13}	3.37	37.63	50.63	88.26	11.2	15.00	7.59

T_1 Conventional 100:60:40 kg N: P_2O_5:K_2O ha^{-1}
T_2 Conventional 2.5t FYM + 80:50:30 kg N: P_2O_5:K_2O ha^{-1}
T_3 Conventional 2.5t FYM + 60:40:20 kg N: P_2O_5:K_2O ha^{-1}
T_4 Conventional 5t FYM + 50:30:20 kg N: P_2O_5:K_2O ha^{-1}
T_5 Conventional 1t PM + 50:30:20 kg N: P_2O_5:K_2O ha^{-1}
T_6 Conventional 2.5t FYM + 0.5t PM + 50:30:20 kg N: P_2O_5:K_2O ha^{-1}
T_7 Pelleted 100:60:40 kg N: P_2O_5:K_2O ha^{-1}
T_8 Pelleted 2.5t FYM + 80:50:30 kg N: P_2O_5:K_2O ha^{-1}
T_9 Pelleted 2.5t FYM + 60:40:20 kg N: P_2O_5:K_2O ha^{-1}
T_{10} Pelleted 5t FYM + 50:30:20 kg N: P_2O_5:K_2O ha^{-1}
T_{11} Pelleted 1t PM + 50:30:20 kg N: P_2O_5:K_2O ha^{-1}
T_{12} Pelleted 2.5t FYM + 0.5t PM+50:30:20 kg N: P_2O_5:K_2O ha^{-1}
T_{13} Control

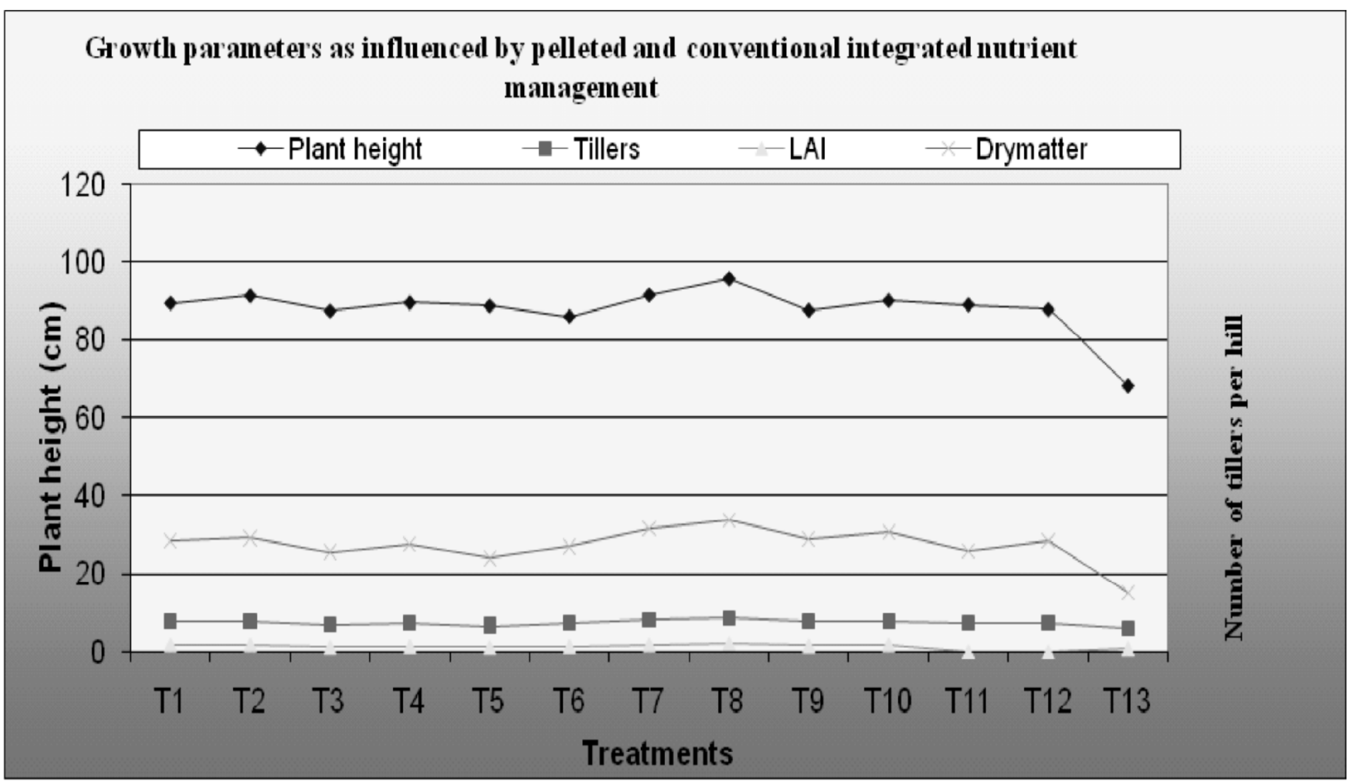

Figure 1: Growth parameters as influenced by pelleted and conventional integrated nutrient management

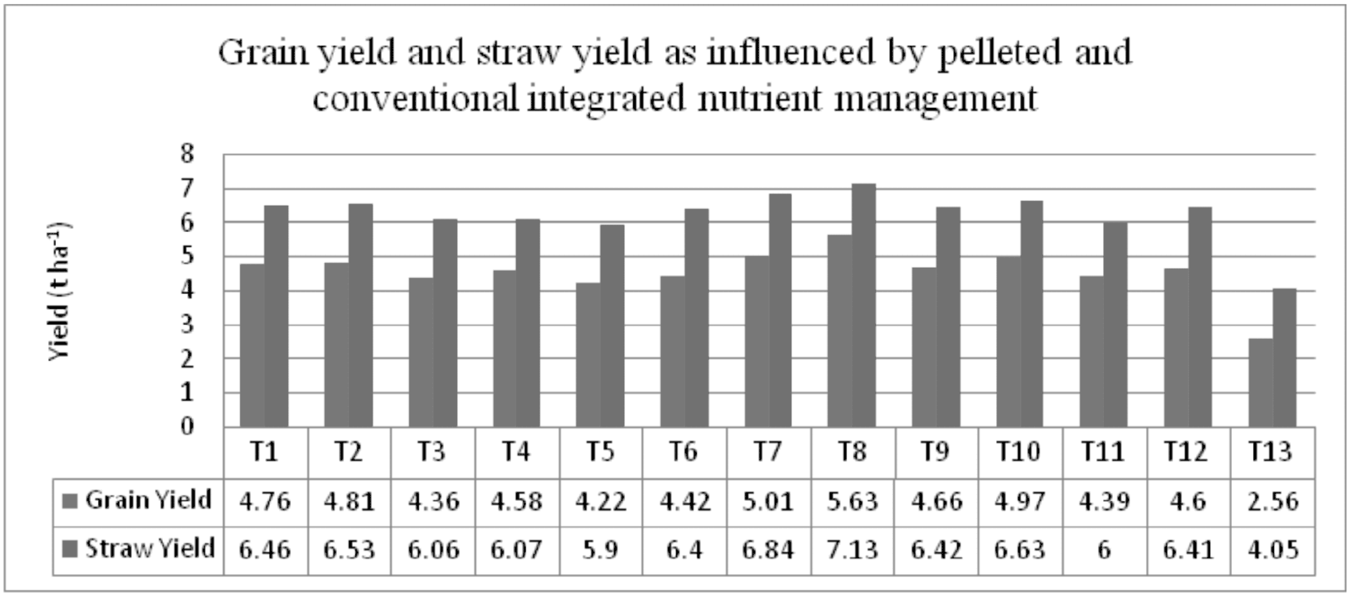

Figure 2: Grain yield and straw yield as influenced by pelleted and conventional integrated nutrient management

(T_2) (Rs. 41607.28 ha^{-1}). The pelleted 2.5t FYM + 80:50:30 kg $N:P_2O_5:K_2O$ ha^{-1} (T_8) recorded higher B:C ratio (2.06) followed by pelleted 5t FYM + 50:30:20 kg $N:P_2O_5:K_2O$ ha^{-1} (T_{10}) 1.76. The lowest value of total input cost (Rs. 22267.00 ha^{-1}), gross return (Rs. 36050.00 ha^{-1}), net return (Rs. 14883.00 ha^{-1}) and B: C ratio (0.70) was recorded under control treatment (T_{13}). Saha and Mondal (2006) reported that maximum net returns and benefit: cost ratio were found under 75% RDF + pelleted form of organic manure.

Energetic: The energy input and output, energy input: output ratio and grain production efficiency are presented in Table 2, indicating great variation in these parameters. The lowest energy input was observed under control treatment (T_{13}), while highest energy input was found under pelleted 100:60:40 kg $N:P_2O_5:K_2O$ ha^{-1} (T_7) followed by conventional 100:60:40 kg $N:P_2O_5:K_2O$ ha^{-1} (T_1). The total energy output was found highest under pelleted 2.5t FYM + 80:50:30 kg N: P_2O_5: K_2O ha^{-1} (T_8) followed by pelleted 100:60:40 kg N: P_2O_5: K_2O ha^{-1} (T_7) treatment. The highest total energy output was mainly due to increased grain and straw yield. The lowest total energy output was observed under control treatment (T_{13}). The maximum grain production efficiency was recorded under control treatment (T_{13}) followed by pelleted 5t FYM + 50:30:20 kg N: P_2O_5: K_2O ha^{-1} (T_{10}) and pelleted 2.5t FYM + 80:50:30 kg N: P_2O_5: K_2O ha^{-1} (T_8). The minimum grain production efficiency was found under conventional 100:60:40 kg N: P_2O_5: K_2O ha^{-1} (T_1) treatment.

ACKNOWLEDGEMENT

Authors are acknowledged to major advisor, Dr. (Major) G.K. Shrivastava and HOD, Department of Agronomy, college of Agriculture, Indira Gandhi Krishi Vishwa Vidyalaya, Raipur, Chhattisgarh (India) for providing guidance in conducting the experiment.

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