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To study the effect of pelleting of organic and inorganic nutrients on Morphophysiological traits and yield of rice under SRI

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Abstract
The experiment was conducted during the *kharif* season of 2015 at Instructional cum Research Farm, IGKV Raipur, to investigate the alternate strategies of innovative pelleting of nutrients to enhance nutrient use efficiency and yield of rice under SRI. The soil was *Inceptisol*, neutral in pH, low in available N medium in available P and high in available K. The 13 treatments consisted of different conventional and innovative pelleting of nutrients was laid out in randomized block design with three replications. The rice variety MTU-1010 was tested under at different conventional and innovative pelleting of nutrients. The results revealed that The treatment pelleted 2.0 t PM + pelleted 80:50:30 $N:P_2O_5:K_2O$ kg ha^{-1} registered higher yield attributing traits *viz.* effective tillers ($hill^{-1}$), panicle weight (g), panicle length (cm), and test weight (g), grain yield (q ha^{-1}) and stover yield (q ha^{-1}) as compared to other treatments.

Keywords: Rice crop, pelleting of nutrients, nutrient use efficiency

Introduction
Rice (*Oryza sativa* L.) is the most important and extensively cultivated food crop that has been referred as "Global Grain" because of its use as prime staple food in about 100 countries of the world. Rice is only cereal that is eaten as whole grain and human selection down the ages has given preference to quality to cater to the needs of diverse rice based preparations. It has occupied an area of 163.20 million hectares, with a total production of 719.70 million tonnes (Anonymous, 2014a) [3].

The System of Rice Intensification (SRI), developed in Madagascar over a 20 year period and synthesized in the early 1980s by Father Henri de Laulanie, offers opportunities to researchers and farmers to expand their understanding of potentials already existing in the rice genome (Uphoff, 2002) [9]. The system of rice intensification (SRI) involves changes in certain management practices which provide better growing conditions for rice plants than traditional practices, particularly in the rhizosphere. In this method, rice seedlings are transplanted early (8 to 12 days old compared to 21 to 25 days in the conventional method). They are transplanted in puddled condition and the seedlings are widely spaced. The fields are alternately kept wet and dry and are not flooded till the panicle initiation stage (1-3 cm of water in the field during the reproductive phase). The field is drained *25* days before harvest and organic manure is used as much as possible. Mechanical weeding is to be done around 10 DAT and at least 2-3 mechanical weeding are necessary, even more are recommended.

Pelleted fertilizers or combinations of organic and inorganic source of nutrients are type of slow release nutrients with long term effects including reduced losses and enhanced uptake. The major advantage over fertilizer is very easy to transport, reducing the losses and efficient to apply. Separate pellets of inorganic fertilizers and organic manure like FYM and poultry manures. Pellet processing of mixed fertilizers and manures were suggested to improve nutrient use efficiency. Pellet of fertilizers coated with a unit of material and FYM or poultry manure, it can be easily manufactured. Pelletisation (i.e. compacting of the organic matter into pellets) can be a valuable process to homogenize, standardize and concentrate the starting material, improving at the same time the uniformity of its fertilizing and amending actions.

Materials and methods
The field experiment was carried out at Research cum Instructional Farm, IGKV, Raipur, during *kharif* season of 2015. The soil of experimental field was '*Inceptisol*' which is locally known as '*Matasi*' The soil was neutral (pH 7.41) in reaction and medium in fertility having 0.44 % soil organic carbon, low N (203.4 kg ha^{-1}), medium P (18.5 kg ha^{-1}) and high K (279.3

kg ha^{-1}). The experiment was laid out in randomized block design with three replications. The treatment consisted of thirteen treatments *viz* T_1 {Conventional 5 t FYM +100:60:40 N:P_2O_5:K_2O kg ha^{-1} (RDF)}, T_2 (Conventional 2.5 t FYM + 80:50:30 N:P_2O_5:K_2O kg ha^{-1}), T_3 (Conventional 2.0 t FYM + 60:40:20 N:P_2O_5:K_2O kg ha^{-1}), T_4 (Conventional 2.0 t PM +80:50:30 N:P_2O_5:K_2O kg ha^{-1}), T_5 (Conventional 1.0 t PM + 60:40:20 N:P_2O_5:K_2O kg ha^{-1}), T_6 (Mixed pelleted 2.5 t FYM + 80:50:30 kg ha^{-1}), medium P (18.5 kg ha^{-1}) and high K (279.3 kg ha^{-1}). The experiment was laid out in randomized block design with three replications. The treatment consisted of thirteen treatments *viz* T_1 {Conventional 5 t FYM +100:60:40 N:P_2O_5:K_2O kg ha^{-1} (RDF)}, T_2 (Conventional 2.5 t FYM + 80:50:30 N:P_2O_5:K_2O kg ha^{-1}), T_3 (Conventional 2.0 t FYM + 60:40:20 N:P_2O_5:K_2O kg ha^{-1}), T_4 (Conventional 2.0 t PM +80:50:30 N:P_2O_5:K_2O kg ha^{-1}), T_5 (Conventional 1.0 t PM + 60:40:20 N:P_2O_5:K_2O kg ha^{-1}), T_6 (Mixed pelleted 2.5 t FYM + 80:50:30 N:P_2O_5:K_2O kg ha^{-1}), T_7 (Mixed pelleted 2.0 t FYM + 60:40:20 N:P_2O_5:K_2O kg ha^{-1}), T_8 (Mixed pelleted 2.0 t PM + 80:50:30 N:P_2O_5:K_2O kg ha^{-1}), T_9 (Mixed pelleted 1.0 t PM + 60:40:20 N:P_2O_5:K_2O kg ha^{-1}), T_{10} (Pelleted 2.5 t FYM + Pelleted 80:50:30 N:P_2O_5:K_2O kg ha^{-1}), T_{11} (Pelleted 2.0 t FYM + Pelleted 60:40:20 N:P_2O_5:K_2O kg ha^{-1}), T_{12} (Pelleted 2.0 t PM + Pelleted 80:50:30 N:P_2O_5:K_2O kg ha^{-1}) and T_{13} (Pelleted 1.0 t PM + Pelleted 60:40:20 N:P_2O_5:K_2O kg ha^{-1}). The MTU-1010 was taken as test crop and transplanted on July 19, 2015 and harvested on November 5, 2015. The experimental crop encountered with an optimum weather conditions throughout the growing season.

Table 1: Quantity of chemical fertilizers, organic manures (kg ha^{-1}) used in different treatments.

Treatment	Chemical fertilizers (kg)			Organic manures (kg)	
	Urea	DAP	MOP	FYM	PM
T_1	166.35	130.44	66.66	5000	0
T_2	131.38	108.7	50	2500	0
T_3	96.41	86.96	33.33	2000	0
T_4	131.38	108.7	50	0	2000
T_5	96.41	86.96	33.33	0	1000
T_6	131.38	108.7	50	2500	0
T_7	96.41	86.96	33.33	2000	0
T_8	131.38	108.7	50	0	2000
T_9	96.41	86.96	33.33	0	1000
T_{10}	131.38	108.7	50	2500	0
T_{11}	96.41	86.96	33.33	2000	0
T_{12}	131.38	108.7	50	0	2000
T_{13}	96.41	86.96	33.33	0	1000
FYM- 0.5:0.25:0.5 N:P_2O_5:K_2O (in %) PM- 1.35:1.0:1.4 N:P_2O_5:K_2O (in %)					

Results and discussion

The results revealed that number of effective tillers hill^{-1} of rice differed significantly due to different treatment under study. The treatment T_{12} (pelleted 2.0 t PM + pelleted 80:50:30 N:P_2O_5:K_2O kg ha^{-1}) recorded highest number of effective tillers hill^{-1} (18.17) as compare to others, however it was comparable to that of treatments T_1 {Conventional 5 t FYM +100:60:40 N:P_2O_5:K_2O kg ha^{-1} (RDF)}, T_2 (Conventional 2.5 t FYM + 80:50:30 N:P_2O_5:K_2O kg ha^{-1}), T_4 (Conventional 2.0 t PM +80:50:30 N:P_2O_5:K_2O kg ha^{-1}), T_6 (Mixed pelleted 2.5 t FYM + 80:50:30 N:P_2O_5:K_2O kg ha^{-1}), T_8 (Mixed pelleted 2.0 t PM + 80:50:30 N:P_2O_5:K_2O kg ha^{-1}) and T_{10} (Pelleted 2.5 t FYM + Pelleted 80:50:30 N:P_2O_5:K_2O kg ha^{-1}). Similar results have also been found by Murali and Setty, 2001 [6].

Table 2: Yield attributing characters of rice as influenced by conventional and innovative pelleting of nutrients

Treatment		Effective tillers (hill^{-1})	Panicle weight (g)	Panicle length (cm)	Test weight (g)
T_1 -	Conventional 5 t FYM +100:60:40 N:P_2O_5:K_2O kg ha^{-1} (RDF)	16.92	3.84	26.10	24.23
T_2-	Conventional 2.5 t FYM + 80:50:30 N:P_2O_5:K_2O kg ha^{-1}	16.41	3.58	25.63	24.86
T_3 -	Conventional 2.0 t FYM + 60:40:20 N:P_2O_5:K_2O kg ha^{-1}	14.34	2.98	23.14	23.33
T_4 -	Conventional 2.0 t PM + 80:50:30 N:P_2O_5:K_2O kg ha^{-1}	16.67	3.67	25.89	24.92
T_5 -	Conventional 1.0 t PM + 60:40:20 N:P_2O_5:K_2O kg ha^{-1}	14.75	3.10	24.21	23.62
T_6 -	Mixed pelleted 2.5 t FYM + 80:50:30 N:P_2O_5:K_2O kg ha^{-1}	17.09	3.81	26.48	25.41
T_7-	Mixed pelleted 2.0 t FYM + 60:40:20 N:P_2O_5:K_2O kg ha^{-1}	15.16	3.21	24.42	23.89
T_8 -	Mixed pelleted 2.0 t PM + 80:50:30 N:P_2O_5:K_2O kg ha^{-1}	17.56	4.02	26.84	25.94
T_9 -	Mixed pelleted 1.0 t PM + 60:40:20 N:P_2O_5:K_2O kg ha^{-1}	15.62	3.44	25.09	24.49
T_{10} -	Pelleted 2.5 t FYM + Pelleted 80:50:30 N:P_2O_5:K_2O kg ha^{-1}	17.32	3.92	26.65	25.58
T_{11} -	Pelleted 2.0 t FYM + Pelleted 60:40:20 N:P_2O_5:K_2O kg ha^{-1}	15.39	3.37	24.88	24.18
T_{12} -	Pelleted 2.0 t PM + Pelleted 80:50:30 N:P_2O_5:K_2O kg ha^{-1}	18.28	4.26	27.39	25.96
T_{13} -	Pelleted 1.0 t PM + Pelleted 60:40:20 N:P_2O_5:K_2O kg ha^{-1}	15.92	3.50	25.47	24.63
SEm±		0.76	0.12	0.81	0.72
CD (P=0.05)		2.22	0.35	2.35	NS

Table 2: Grain yield (q ha^{-1}), Straw yield (q ha^{-1}) and Harvest index (%) of rice as influenced by conventional and innovative pelleting of nutrients.

Treatment		Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest index (%)
T_1 -	Conventional 5 t FYM +100:60:40 N:P_2O_5:K_2O kg ha^{-1} (RDF)	44.97	60.90	42.50
T_2-	Conventional 2.5 t FYM + 80:50:30 N:P_2O_5:K_2O kg ha^{-1}	42.48	58.54	42.05
T_3 -	Conventional 2.0 t FYM + 60:40:20 N:P_2O_5:K_2O kg ha^{-1}	34.62	51.22	40.35
T_4 -	Conventional 2.0 t PM + 80:50:30 N:P_2O_5:K_2O kg ha^{-1}	43.87	59.11	42.60
T_5 -	Conventional 1.0 t PM + 60:40:20 N:P_2O_5:K_2O kg ha^{-1}	35.92	52.78	40.54
T_6 -	Mixed pelleted 2.5 t FYM + 80:50:30 N:P_2O_5:K_2O kg ha^{-1}	49.08	64.28	43.30
T_7-	Mixed pelleted 2.0 t FYM + 60:40:20 N:P_2O_5:K_2O kg ha^{-1}	36.02	51.55	41.14
T_8 -	Mixed pelleted 2.0 t PM + 80:50:30 N:P_2O_5:K_2O kg ha^{-1}	51.79	66.03	43.96
T_9 -	Mixed pelleted 1.0 t PM + 60:40:20 N:P_2O_5:K_2O kg ha^{-1}	37.81	53.73	41.29
T_{10} -	Pelleted 2.5 t FYM + Pelleted 80:50:30 N:P_2O_5:K_2O kg ha^{-1}	50.38	65.81	43.35
T_{11} -	Pelleted 2.0 t FYM + Pelleted 60:40:20 N:P_2O_5:K_2O kg ha^{-1}	36.68	53.58	40.64
T_{12} -	Pelleted 2.0 t PM + Pelleted 80:50:30 N:P_2O_5:K_2O kg ha^{-1}	53.85	68.17	44.15
T_{13} -	Pelleted 1.0 t PM + Pelleted 60:40:20 N:P_2O_5:K_2O kg ha^{-1}	38.29	55.88	40.67
SEm±		1.38	2.12	0.41
CD(P=0.05)		4.03	6.20	1.20

The significantly highest panicle weight (4.26 g) was recorded under the treatment T_{12} (pelleted 2.0 t PM + pelleted 80:50:30 N:P_2O_5:K_2O kg ha^{-1}), which was found comparable with the treatments T_8 (mixed pelleted 2.0 t PM + 80:50:30 N:P_2O_5:K_2O kg ha^{-1}) and T_{10} (pelleted 2.5 t FYM + pelleted 80:50:30 N:P_2O_5:K_2O kg ha^{-1}). These results are in conformity with findings of Setty *et al.* (2007) [7]. The treatment T_{12} (pelleted 2.0 t PM + pelleted 80:50:30 N:P_2O_5:K_2O kg ha^{-1}) registered significantly longest panicle (27.39 cm) which was found to be at par with treatments T_1 {conventional 5 t FYM +100:60:40 N:P_2O_5:K_2O kg ha^{-1} (RDF)}, T_2 (conventional 2.5 t FYM + 80:50:30 N:P_2O_5:K_2O kg ha^{-1}), T_4 (conventional 2.0 t PM +80:50:30 N:P_2O_5:K_2O kg ha^{-1}), T_6 (mixed pelleted 2.5 t FYM + 80:50:30 N:P_2O_5:K_2O kg ha^{-1}), T_8 (mixed pelleted 2.0 t PM + 80:50:30 N:P_2O_5:K_2O kg ha^{-1}), T_9 (mixed pelleted 1.0 t PM + 60:40:20 N:P_2O_5:K_2O kg ha^{-1}) and T_{10} (pelleted 2.5 t FYM + pelleted 80:50:30 N:P_2O_5:K_2O kg ha^{-1}). The maximum test weight (25.96 g) was recorded in treatment T_{12} (pelleted 2.0 t PM + pelleted 80:50:30 N:P_2O_5:K_2O kg ha^{-1}) which was significantly superior over others. The same results were reported by El-Kramany (2001) [4] and Amany *et al.* (2006) [2] in wheat and maize, respectively.

The results related to grain yield was significantly highest under treatment T_{12} (pelleted 2.0 t PM + pelleted 80:50:30 N:P_2O_5:K_2O kg ha^{-1}) however, it was at par to treatments T_8 (mixed pelleted 2.0 t PM + 80:50:30 N:P_2O_5:K_2O kg ha^{-1}) and T_{10} (pelleted 2.5 t FYM + pelleted 80:50:30 N:P_2O_5:K_2O kg ha^{-1}). The similar results have also been found by Jha *et al.* (2006) [6], Wild *et al.* (2011) [10] and Singh *et al.* (2013) [8]. However, significantly higher straw yield of rice was recorded with treatment T_{12} (Pelleted 2.0 t PM + Pelleted 80:50:30 N:P_2O_5:K_2O kg ha^{-1}) as compared to others but it was at par to treatments T_6 (mixed pelleted 2.5 t FYM + 80:50:30 N:P_2O_5:K_2O kg ha^{-1}), T_8 (mixed pelleted 2.0 t PM + 80:50:30 N:P_2O_5:K_2O kg ha^{-1}), T_9 (mixed pelleted 1.0 t PM + 60:40:20 N:P_2O_5:K_2O kg ha^{-1}) and T_{10} (pelleted 2.5 t FYM + pelleted 80:50:30 N:P_2O_5:K_2O kg ha^{-1}).

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