I.J.S.N., VOL.7 (3) 2016: 604-610 ISSN 2229 – 6441

INTERNATIONAL JOURNAL OF SCIENCE AND NATURE

www.scienceandnature.org

IMPROVED PHYSIOLOGICAL PARAMETERS, YIELD, ELEMENTAL COMPOSITION AND QUALITY OF HYBRID RICE THROUGH NUTRIENT MANAGEMENT MODULES

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ABSTRACT
The field investigation was carried out to evaluate the impact of various nutrient management modules on physiological parameters, yield, elemental composition and quality of hybrid rice during 2004-05 and 2005-06 at Instructional Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad, Uttar Pradesh, India. The experiment comprised of eighteen treatments and tested in randomized block design and replicated three times. The maximum leaf area index and chlorophyll content was recorded under treatment having 100% NPK along with 5 t pressmud. Significantly higher grain yield was recorded under treatment having 100% NPK + 5 t pressmud over all the treatment except treatment T_1, T_2, T_4, T_5 and T_6 which were at par. Maximum N content at tillering, panicle initiation and at harvest stage in grains and straw was determined under treatment having 100% NPK + 5 t pressmud and observed significantly superior over 50%, 75% and 100% NPK alone. P and K content in rice at tillering, panicle initiation and harvest stage in grain and straw improved with increasing levels of NPK either alone or in combination with FYM and pressmud. Hulling, milling percentage and protein content increased significantly under all nutrient management modules consisting either 10 t FYM or 5 t pressmud along with inorganic levels of fertilizer over inorganic levels (100%, 75% and 50% NPK) of fertilizer alone. Reduction in inorganic fertilizer doses of NPK causes significant reduction in hulling, milling and protein content. Highest hulling, milling and protein content were estimated with treatment combination of 100% NPK + 5 t pressmud ha^{-1}.

KEYWORDS: Yield, hybrid rice, NPK and Zn content, hulling, milling, protein and nutrient management module.

INTRODUCTION
Asian farmers produce more than 90% of rice dominated by India and China, growing more than half of the total rice production (IARI, 2011). Rice occupies largest area among all the crops grown in India. It is estimated that India will need to produce more rice if it is to meet the growing demand, likely to be 130 million tonnes of milled rice by 2030 with limited natural resources and less human resource power (Gujja and Thiyagarajan, 2009). Among the various approaches contemplated to break the existing yield barriers in rice to feed the rising population, hybrid technology is considered as one of the promising sustainable and ecofriendly technologies (Sarkar *et al.*, 2002). The basic concept underlying the principles of nutrient management modules is the maintenance and possibly improvement of soil fertility for sustainable crop productivity on long term basis, which may be achieved through combined use of all possible source of nutrient and their scientific management for optimum growth, yield and quality of crops and cropping system in specific agro-ecological situation without impairing natural condition. Soil fertility is a prerequisite to its productivity. From the stand point of crop yield and quality, nutrient supply both from organic and inorganic source are important. Use of local bio-degradable, non-toxic and cost effective agro waste can be well affordable for the Indian agrarian (Ashok *et al*., 2015). Similarly, application of green manure along with chemical fertilizers resulted higher organic carbon status and reduced the gap between potential and actual yield to a large extent (Kumar and Prasad, 2008). Therefore, efficient fertilizer management under environment friendly condition is crucial to increase rice production worldwide (Naher *et al*., 2011). Keeping in view the above facts the present investigation was, therefore, carried out with a view to evaluate various nutrient management modules for sustaining productivity and quality of hybrid rice and also improving locally available resource use efficiency and minimizing environmental hazards.

MATERIALS & METHODS
The present study was carried at Instructional Farm of Narendra Deva University of Agriculture and Technology, Kumarganj during *kharif* 2004-05 and 2005-06. The aim of this study was to assess the effect of nutrient management modules on physiological parameters, yield, nutrient content and quality of hybrid rice. The experimental site falls under subtropical zone in Indo-Gangetic plains having alluvial soil and lies between latitude 26.47° N and at longitude 82.12° E with elevation of about 113 m from sea level. The soil of the experimental field was low in organic carbon and N, medium in P_2O_5 and K_2O. The experimental field was under rice-wheat cropping system since 1999. The modules consisting of different inorganic and organic sources and NPK levels were applied as per treatment. The

experiment comprised of eighteen treatments viz., T_1 (100% NPK), T_2 (100% NPK + 10 t FYM), T_3 (100% NPK + 5 t pressmud), T_4 (100% NPK + 5 t water hyacinth), T_5 (100% NPK + 5 t green manure), T_6 (100% NPK + 10 kg BGA Crust), T_7 (75%, NPK), T_8 (75% NPK + 10 t FYM), T_9 (75% NPK + 5 t pressmud), T_{10} (75% NPK + 5 t water hyacinth), T_{11} (75% NPK + 5 t green manure), T12 (75% NPK + BGA), T13 (50% NPK) T_{14} (50% NPK + 10 t + FYM), T_{15} (50% NPK + 5 t pressmud), T_{16} (50% NPK + 5 t water hyacinth), T_{17} (50% NPK + 5 t green manure) and T_{18} (50% NPK + 10 kg BGA crust) tested in randomized block design and replicated three times. The rice hybrid variety RPH-2 (Tata Rallies hybrid rice) was taken as test crop. All the treatments to the plots were allotted randomly. Treatment was incorporated uniformly in the plots. FYM and pressmud was incorporated uniformly in the respective plots seven days before transplanting of rice seedling to the depth of 10-15 cm. Water hyacinth was applied in the field fifteen days before transplanting of the rice and was uniformly mixed in soil. The treated plots were left for fifteen days in order to facilitate the decomposition of water hyacinth. The species of dhaincha (*Sesbania aculeata*) was collected from the outside field where it was already grown. The Sesbania green manure crop was cut down after chopping with the help of sickle and it was incorporated in to the field according to treatment in to the top fifteen cm soil one week before of rice transplanting. BGA crust as per treatment was incorporated uniformly in the plots twenty days after transplanting of rice crop. Full dose of P_2O_5 and K_2O and half dose of N were applied as basal as per treatment while remaining half dose of N was applied in two equal splits at tillering and panicle initiation stages. A common dose of zinc sulphate @ 25 kg ha^{-1} was also applied at the time of transplanting. Before transplanting of rice, plots were flooded with water and puddled. The nursery beds were irrigated a day prior to uprooting of seedlings to avoid roots injury. Seedling were uprooted by holding the seedling at the base and pulled up one by one. Then seedling roots were washed to remove the soil adhering to roots. Transplanting was done manually at 20 cm x 15 cm distance using one seedling per hill. A week after transplanting, gap filling was done by planting seedlings from the same nursery to maintain optimum plant population. A thin film of water (2-3 cm) was maintained during the initial stage of seedling establishment. Thereafter, crop was irrigated as and when required to maintain the water level. Weeds were removed manually at 20 and 40 days after transplanting. Maintenance of water level also helped to reduce the weed population in the plots. Chlorophyll content was estimated by method described by Arnon (1949). The leaf area index (LAI) was recorded at panicle initiation stage. The leaf area of one leaf was multiplied by total numbers of leaves present in a unit area to obtain total LAI. The samples of rice plants at tillering and panicle initiation stage as well as grain and straw samples at harvest stage were analyzed for total NPK and Zn content. Samples were air dried followed by according to facilitate fine grinding. The finally ground material, passed through 0.4 mm sieve was analyzed using different methods for various nutrient content. Thoroughly powdered grain and straw samples of rice were digested with concentrated H_2SO_4 in presence of catalyst mixture. Modified Kjeldahl's method was followed for determination of N content in plant and grains as described by (Jackson, 1973). A known weight of plant material was digested with triacid mixture having nitric, per-chloric and sulphuric acid in 10:4:1 ratio. P was determined in the digested plant material by vanado-molybdate phosphoric yellow colour method as described by Jackson (1973). The known weight of plant sample was digested with di-acid mixture having nitric acid and perchloric acid in 2:1 ratio and K was determined by flame photometer (Jackson, 1973). Zn content was determined in plant samples by measuring the intensity of colour on atomic absorption spectrophotometer by using zinc hollow cathode lamp (Lindsey and Narwell, 1978). The crop was harvested manually with the help of sickle when more than 90 per cent of the grains in the panicle were fully ripped and free from greenish tint. After taking the bundles weight of the harvested produce of each net plot, their grains were separated manually. The produce was then dried in the sun so as to obtain uniform moisture in the grains. The grain yield was recorded at 14 per cent moisture from each net plot after threshing and the values were converted to q ha^{-1}. The paddy seeds were separately taken and removed the rice husk by manually and thus the kernal weight was recorded and calculated the hulling percentage. The kernal bran was removed manually by sand paper and finally weight was calculated for milling. To obtain crude protein in hybrid rice grains the nitrogen percentage was multiplied by 6.25 (A.O.A.C., 1970). The experimental data were analyzed using "Analysis of variance technique" in randomized block design. The critical differences at 5 per cent level of probability were calculated for testing the significance of difference between any two means whereas 'F' test was significant (Snedecor and Cochsan, 1967).

RESULTS & DISCUSSION

LAI

Data presented on LAI at panicle initiation stage clearly revealed that various treatments were found statistically non-significant; however, maximum LAI was recorded under treatment supplied 100% NPK + 5 t pressmud (Table 1). This might be because of relatively more supply of required nutrients and better soil environment under this treatment, which increased photosynthesis, promotes the metabolic activities and accelerates cell division ultimately increases the growth and development of leaves in terms of LAI. These results corroborates with the findings of Singh (2004).

Chlorophyll content

Among various treatments, highest chlorophyll content was found with application of 100% NPK + 5 t pressmud followed by 100% NPK + 10 t FYM (Table 1). The increased chlorophyll content under the pressmud and FYM along with 100% NPK plots might be because of enhanced photosynthesis, nitrogen metabolism, transformation of carbohydrates and oxidation-reduction process in plants. Similarly, Singh (2013) reported highest chlorophyll content in hybrid rice with treatment having 75%RDF + green manuring of dhaincha.

TABLE 1: Impact of various nutrient management modules on LAI and chlorophyll content in rice leaves

Treatments	LAI		Chlorophyll content mg g^{-1} fresh wt.	
	2004	2005	2004	2005
T_1 100% NPK (150:75:75 NPK Kg ha-1)	5.14	5.02	2.29	2.18
T2 100% NPK + 10 t FYM ha-1	5.35	5.26	2.50	2.42
T3 100% NPK + 5 t pressmud ha-1	5.38	5.27	2.57	2.46
T4 100% NPK + 5 t water hyacinth ha-1	5.28	5.16	2.47	2.34
T5 100% NPK + 5 t Sesbania (Green manure) ha-1	5.32	5.21	2.48	2.37
T6 100% NPK + 10 kg BGA crust ha-1	5.20	5.11	2.37	2.28
T7 75% NPK (112.5:56.25:56.25 NPK Kg ha-1)	4.87	4.76	1.90	1.79
T8 75% NPK + 10 t FYM ha-1	5.05	5.00	2.26	2.17
T9 75% NPK + 5 t pressmud ha-1	5.10	5.02	2.31	2.23
T10 75% NPK + 5 t water hyacinth ha-1	5.00	4.91	2.17	2.08
T11 75% NPK + 5 t Sesbania (Green manure) ha-1	5.05	4.95	2.15	2.13
T12 75% NPK + 10 kg BGA crust ha-1	4.95	4.82	2.10	2.02
T13 50% NPK (75: 37.5:37.5 NPK Kg ha-1)	4.50	4.41	1.49	1.37
T14 50% NPK + 10 t FYM ha-1	4.83	4.70	1.80	1.70
T15 50% NPK + 5 t pressmud ha-1	4.89	4.72	1.86	1.74
T16 50% NPK + 5 t water hyacinth ha-1	4.65	4.53	1.69	1.56
T17 50% NPK + 5 t Sesbania (Green manure) ha-1	4.73	4.62	1.75	1.64
T18 50% NPK + 10 kg BGA crust ha-1	4.63	4.55	1.69	1.58
SEm ±	0.35	0.40	0.23	0.24
C.D. (P=0.05)	NS	NS	0.66	0.69

Grain yield

Grain yield of hybrid rice was significantly influenced by various nutrient management modules (Fig. 1). Maximum grain yield (70.15 and 67.12 q ha^{-1}) of rice crop was recorded under nutrient management module of 100% NPK + 5 t pressmud closely followed by 100% NPK + 10 t FYM. Significantly higher grain yield was recorded under treatment having 100% NPK + 5 t pressmud over all the treatment except treatment T_1, T_2, T_4, T_5 and T_6 which were recorded at par. Among the various nutrient management modules application of 5 t pressmud ha^{-1} found to be most superior at 100% NPK, 75% NPK as well as 50% NPK levels considering the grain yield of hybrid rice. The increase in grain yield might be due to improved yield attributes, morphological and biological characters and better translocation of photosynthates from source to sink. Better crop growth was observed in pressmud treated plot might be due to its effectiveness in the improvement of physical as well as chemical properties of the soil and providing good environment to plant. These results corroborates with the findings of Singh *et al.* (1994), Verma and Acharya (2004) and Singh (2005). Similarly, Singh (2014 b) reported highest yield from plot treated with 75% RDF+ green manure along with 40 kg zinc sulphate ha^{-1}.

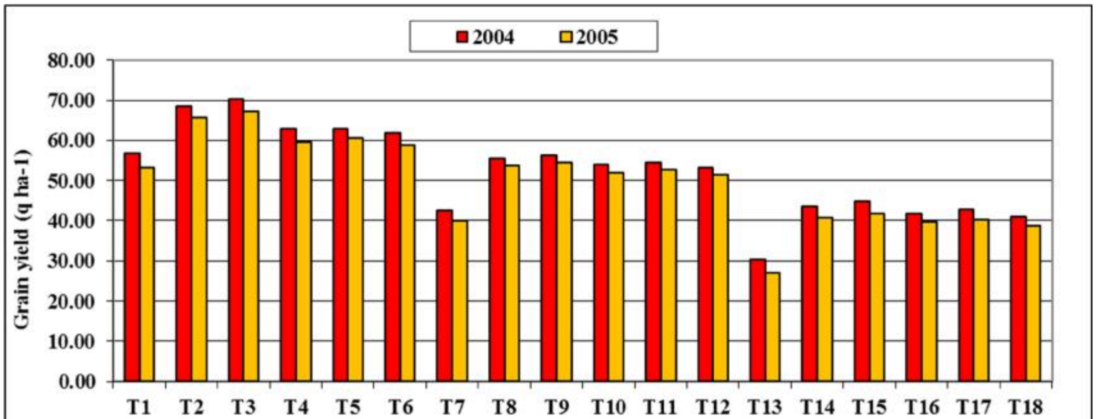

Figure 1 Effect of nutrient management modules on grain yield

N content

Significant increase in N content observed with pressmud and FYM along with 100%, 75% and 50% NPK over its 100%, 75% and 50% NPK alone treatment (Table 2). Application of water hyacinth green manure and BGA along with 100%, 75% and 50% NPK did not reflect any significant difference over 100%, 75% and 50% NPK alone treatment. This can be explained on the basis of adequate supply of N and its absorption by the crop at optimal level of fertilizer alone as well as in combination with FYM, pressmud, water hyacinth, green manure, BGA. These results corroborates with the findings of Mondal *et al.* (1994), Singh *et al.* (1994), Kumar and Yadav (1995), Kumar *et al.* (2001) and Mahapatra and Sharma (2003).

TABLE 2: N content (%) in rice at different growth stages under various nutrient management modules

Treatments	Tillering stage		Panicle initiation		At harvest			
					Grain		Straw	
	2004	2005	2004	2005	2004	2005	2004	2005
T_1 100% NPK (150:75:75 NPK Kg ha-1)	1.70	1.62	1.50	1.45	1.20	1.18	0.51	0.49
T2 100% NPK + 10 t FYM ha-1	1.80	1.72	1.58	1.54	1.26	1.24	0.59	0.58
T3 100% NPK + 5 t pressmud ha-1	1.81	1.73	1.59	1.55	1.27	1.25	0.61	0.60
T4 100% NPK + 5 t water hyacinth ha-1	1.76	1.68	1.55	1.51	1.23	1.22	0.55	0.53
T5 100% NPK + 5 t Sesbania (Green manure) ha-1	1.77	1.69	1.57	1.52	1.23	1.23	0.55	0.54
T6 100% NPK + 10 kg BGA crust ha-1	1.75	1.67	1.55	1.51	1.22	1.21	0.54	0.52
T7 75% NPK (112.5:56.25:56.25 NPK Kg ha-1)	1.62	1.53	1.43	1.38	1.15	1.13	0.44	0.42
T8 75% NPK + 10 t FYM ha-1	1.73	1.64	1.51	1.47	1.22	1.19	0.50	0.48
T9 75% NPK + 5 t pressmud ha-1	1.74	1.65	1.53	1.49	1.23	1.20	0.51	0.50
T10 75% NPK + 5 t water hyacinth ha-1	1.68	1.60	1.48	1.43	1.18	1.16	0.47	0.46
T11 75% NPK + 5 t Sesbania (Green manure) ha-1	1.70	1.61	1.49	1.44	1.20	1.17	0.48	0.47
T12 75% NPK + 10 kg BGA crust ha-1	1.68	1.60	1.48	1.43	1.18	1.15	0.47	0.45
T13 50% NPK (75: 37.5:37.5 NPK Kg ha-1)	1.55	1.44	1.35	1.31	1.09	1.07	0.40	0.39
T14 50% NPK + 10 t FYM ha-1	1.66	1.55	1.44	1.41	1.16	1.14	0.46	0.45
T15 50% NPK + 5 t pressmud ha-1	1.68	1.58	1.45	1.43	1.18	1.16	0.47	0.47
T16 50% NPK + 5 t water hyacinth ha-1	1.62	1.51	1.40	1.36	1.13	1.11	0.42	0.40
T17 50% NPK + 5 t Sesbania (Green manure) ha-1	1.63	1.52	1.41	1.37	1.13	1.11	0.44	0.42
T18 50% NPK + 10 kg BGA crust ha-1	1.62	1.51	1.40	1.36	1.12	1.10	0.42	0.40
SEm ±	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02
C.D. (P=0.05)	0.10	0.10	0.08	0.08	0.06	0.06	0.05	0.06

P content

Significant improvement in P content in plant was observed under treatments FYM and pressmud along with 100%, 75% and 50% NPK over 100%, 75% and 50% NPK alone (Table 3). This might be due to application of FYM and pressmud which produces organic and weak acids, ultimately increases the availability of P. Therefore, enhanced P availability and increases its absorption by plant. These results are in accordance with the findings of Kumar and Yadav (1995), Santhy *et al.* (1998) and Singh (2005).

TABLE 3: P content (%) in rice plant at different growth stages under various nutrient management modules

Treatments	Tillering stage		Panicle initiation		At harvest			
					Grain		Straw	
	2004	2005	2004	2005	2004	2005	2004	2005
T_1 100% NPK (150:75:75 NPK Kg ha-1)	0.27	0.24	0.22	0.21	0.25	0.22	0.072	0.070
T2 100% NPK + 10 t FYM ha-1	0.35	0.30	0.28	0.28	0.31	0.28	0.087	0.083
T3 100% NPK + 5 t pressmud ha-1	0.36	0.31	0.30	0.29	0.32	0.29	0.089	0.088
T4 100% NPK + 5 t water hyacinth ha-1	0.31	0.27	0.26	0.24	0.28	0.25	0.073	0.071
T5 100% NPK + 5 t Sesbania (Green manure) ha-1	0.32	0.28	0.27	0.26	0.29	0.26	0.075	0.072
T6 100% NPK + 10 kg BGA crust ha-1	0.31	0.26	0.25	0.22	0.28	0.25	0.072	0.071
T7 75% NPK (112.5:56.25:56.25 NPK Kg ha-1)	0.22	0.21	0.17	0.18	0.23	0.20	0.063	0.061
T8 75% NPK + 10 t FYM ha-1	0.30	0.26	0.24	0.25	0.28	0.26	0.078	0.075
T9 75% NPK + 5 t pressmud ha-1	0.31	0.27	0.25	0.26	0.29	0.26	0.079	0.077
T10 75% NPK + 5 t water hyacinth ha-1	0.26	0.23	0.21	0.20	0.26	0.23	0.064	0.064
T11 75% NPK + 5 t Sesbania (Green manure) ha-1	0.27	0.24	0.22	0.21	0.27	0.24	0.066	0.065
T12 75% NPK + 10 kg BGA crust ha-1	0.26	0.22	0.20	0.18	0.26	0.23	0.064	0.064
T13 50% NPK (75: 37.5:37.5 NPK Kg ha-1)	0.17	0.16	0.15	0.13	0.21	0.18	0.055	0.053
T14 50% NPK + 10 t FYM ha-1	0.24	0.21	0.22	0.21	0.27	0.24	0.068	0.066
T15 50% NPK + 5 t pressmud ha-1	0.26	0.23	0.22	0.22	0.28	0.24	0.069	0.067
T16 50% NPK + 5 t water hyacinth ha-1	0.20	0.17	0.17	0.17	0.24	0.21	0.057	0.055
T17 50% NPK + 5 t Sesbania (Green manure) ha-1	0.20	0.18	0.18	0.18	0.25	0.22	0.058	0.056
T18 50% NPK + 10 kg BGA crust ha-1	0.19	0.17	0.17	0.16	0.24	0.21	0.056	0.055
SEm ±	0.02	0.02	0.02	0.02	0.02	0.02	0.003	0.003
C.D. (P=0.05)	0.07	0.05	0.06	0.07	0.06	0.05	0.01	0.01

K content

The maximum K content in plant was recorded at tillering stage, which reduces towards the maturity of crop this may be due to dilution effect and increase in biomass of crop (Table 4). Application of FYM and pressmud along with 100%, 75% and 50% NPK recorded significantly superior in K content over 100%, 75% and 50% NPK alone. Increase in K content under these treatments might be due to its sufficient supply from soil to the plants. These findings are also in agreement with the results obtained by Bindra and Thakur (1994), Kumar and Yadav (1995) and Dudhan *et al.* (2004).

TABLE 4: K content (%) in rice at various growth stages under influence of various nutrient management modules

Treatments	Tillering stage		Panicle initiation		At harvest			
					Grain		Straw	
	2004	2005	2004	2005	2004	2005	2004	2005
T_1 100% NPK (150:75:75 NPK Kg ha-1)	1.95	1.89	1.81	1.75	0.76	0.71	1.24	1.19
T2 100% NPK + 10 t FYM ha-1	2.06	1.97	1.92	1.86	0.87	0.81	1.30	1.26
T3 100% NPK + 5 t pressmud ha-1	2.08	1.98	1.93	1.87	0.88	0.82	1.32	1.28
T4 100% NPK + 5 t water hyacinth ha-1	2.02	1.95	1.88	1.83	0.80	0.76	1.28	1.23
T5 100% NPK + 5 t Sesbania (Green manure) ha-1	2.03	1.96	1.89	1.84	0.80	0.75	1.29	1.24
T6 100% NPK + 10 kg BGA crust ha-1	2.00	1.94	1.88	1.80	0.79	0.74	1.26	1.21
T7 75% NPK (112.5:56.25:56.25 NPK Kg ha-1)	1.86	1.78	1.70	1.65	0.68	0.65	1.15	1.08
T8 75% NPK + 10 t FYM ha-1	1.95	1.89	1.80	1.75	0.79	0.76	1.21	1.17
T9 75% NPK + 5 t pressmud ha-1	1.96	1.90	1.82	1.76	0.80	0.77	1.23	1.20
T10 75% NPK + 5 t water hyacinth ha-1	1.93	1.84	1.78	1.73	0.74	0.70	1.19	1.13
T11 75% NPK + 5 t Sesbania (Green manure) ha-1	1.94	1.85	1.79	1.74	0.75	0.71	1.20	1.14
T12 75% NPK + 10 kg BGA crust ha-1	1.93	1.83	1.77	1.73	0.73	0.70	1.19	1.13
T13 50% NPK (75: 37.5:37.5 NPK Kg ha-1)	1.77	1.72	1.60	1.55	0.57	0.57	1.10	1.07
T14 50% NPK + 10 t FYM ha-1	1.86	1.81	1.72	1.66	0.68	0.68	1.19	1.14
T15 50% NPK + 5 t pressmud ha-1	1.87	1.83	1.72	1.68	0.69	0.69	1.19	1.15
T16 50% NPK + 5 t water hyacinth ha-1	1.84	1.78	1.68	1.63	0.65	0.60	1.08	1.07
T17 50% NPK + 5 t Sesbania (Green manure) ha-1	1.85	1.79	1.68	1.64	0.66	0.61	1.09	1.08
T18 50% NPK + 10 kg BGA crust ha-1	1.84	1.76	1.68	1.62	0.65	0.60	1.08	1.07
SEm ±	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02
C.D. (P=0.05)	0.09	0.08	0.10	0.10	0.10	0.10	0.06	0.07

Zn content

Effect of various nutrient management modules showed that highest Zn content was estimated under treatment having 100% NPK + 5 t pressmud followed by 100% NPK + 10 t FYM at all the stages of crop growth (Fig. 2&3). The increase in Zn content under treatments having FYM and PM treated plots might be due to chelating effect and improved native as well as added Zn in soil at all the growth stages. These results closely related to the findings of Kumar *et al.* (2001).

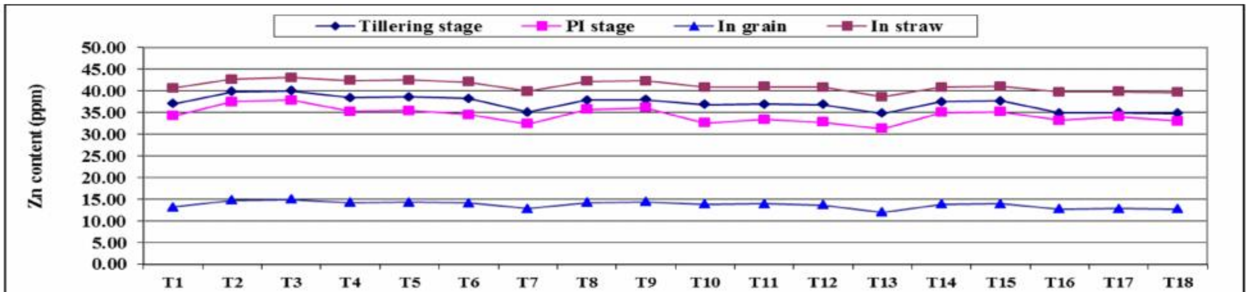

Figure 2 Effect of nutrient management modules on Zn conent at various growth stages of rice crop during 2004

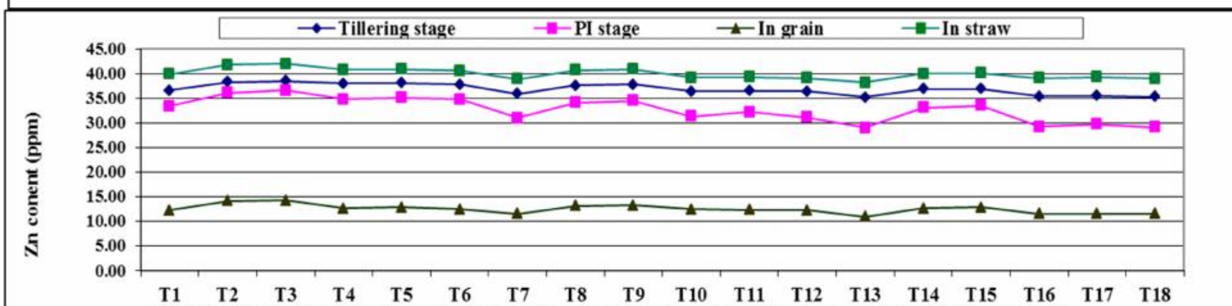

Figure 3 Effect of nutrient management modules on Zn content at various growth stages of rice crop during 2005

Hulling and Milling

Data pertaining to hulling and milling percentage presented in Table 5 revealed that all the treatments were significantly superior over treatment T_{13} (50% NPK alone). Hulling and milling percentage was recorded maximum under treatment T_3 having 100% NPK + 5 t pressmud followed by treatment T_2 (100% NPK + 10 t FYM). However, significantly higher hulling and milling percentage was resulted with the composition of inorganic (100%, 75% and 50 % NPK) fertilizer along with organic (FYM, PM, WH, GM and BGA) manures as compared to inorganic fertilizers alone, respectively. It is due to the balanced application of nutrients which improved grain quality of rice. These results corroborate with the findings of Krishna and Ram (2006) and Singh (2014 a).

TABLE 5: Hulling, milling and protein content in hybrid rice under various nutrient management modules

Treatments	Hulling (%)		Milling (%)		Protein content (%)	
	2004	2005	2004	2005	2004	2005
T_1 100% NPK (150:75:75 NPK Kg ha-1)	74.65	74.24	70.27	69.60	7.50	7.37
T2 100% NPK + 10 t FYM ha-1	75.98	75.67	72.39	71.50	7.87	7.75
T3 100% NPK + 5 t pressmud ha-1	76.15	75.98	72.49	71.96	7.93	7.81
T4 100% NPK + 5 t water hyacinth ha-1	74.90	74.50	71.39	70.88	7.68	7.62
T5 100% NPK + 5 t Sesbania (Green manure) ha-1	75.10	74.85	71.60	71.30	7.68	7.68
T6 100% NPK + 10 kg BGA crust ha-1	74.70	74.30	71.20	70.63	7.62	7.56
T7 75% NPK (112.5:56.25:56.25 NPK Kg ha-1)	73.25	72.65	68.08	67.68	7.18	7.06
T8 75% NPK + 10 t FYM ha-1	74.90	74.45	71.37	70.64	7.62	7.43
T9 75% NPK + 5 t pressmud ha-1	75.10	74.90	71.76	71.50	7.68	7.50
T10 75% NPK + 5 t water hyacinth ha-1	74.64	74.15	69.94	69.50	7.37	7.25
T11 75% NPK + 5 t Sesbania (Green manure) ha-1	74.85	74.30	70.06	69.68	7.50	7.31
T12 75% NPK + 10 kg BGA crust ha-1	74.60	74.10	69.76	68.99	7.37	7.18
T13 50% NPK (75: 37.5:37.5 NPK Kg ha-1)	71.65	71.15	65.52	65.00	6.81	6.68
T14 50% NPK + 10 t FYM ha-1	73.45	73.05	68.85	68.41	7.25	7.12
T15 50% NPK + 5 t pressmud ha-1	74.55	73.25	70.21	68.92	7.37	7.25
T16 50% NPK + 5 t water hyacinth ha-1	73.20	72.85	67.83	67.33	7.06	6.94
T17 50% NPK + 5 t Sesbania (Green manure) ha-1	73.30	72.95	67.95	67.56	7.06	6.94
T18 50% NPK + 10 kg BGA crust ha-1	73.05	72.60	67.70	67.22	7.00	6.87
SEm ±	0.45	0.49	0.57	0.63	0.12	0.13
C.D. (P=0.05)	1.31	1.40	1.65	1.80	0.34	0.36

Protein content

The protein content in grain increased significantly with the treatments consists of various doses of NPK along with pressmud and FYM (Table 5). However, maximum protein content in grains was recorded with treatment consisting 100% NPK + 5 t pressmud followed by treatment T_2 (100% NPK + 10 t FYM). Protein content increased because of higher N utilization by the crop, which enhance the protein synthesis in plants and ultimately increased the protein content in rice grain by increasing the osmophyllic bodies and formation of amino acids. The increase in protein content due to enhancement of N uptake in these treatments may be due to the adequate N availability in soil which increased the N absorption by the plants which ultimately increased N content in grain and increases the protein content. These results are in accordance with the findings of Mondal *et al.* (1994), Singh *et al.* (1994) and Krishna and Ram (2006).

CONCLUSION

On the basis of results summarized above the following specific conclusion are being warranted that treatment module of 100% NPK + 5 t pressmud ha^{-1} resulted higher physiological performance and yield of hybrid rice crop. Quality components of rice like hulling, milling and protein content were also improved to considerable extent. Among various growth stages, the maximum N, P, K and Zn content in plant was at tillering stage, which reduced progressively towards the maturity of crop. The decrease in nutrient contents at advance stages of crop might be due to dilution effect and increased mass of dry matter.

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