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Effects of Integrated Nutrient Management on Rice (Oryza sativa L) Yield and Yield Attributes, Nutrient Uptake and Some Physico-Chemical Properties of Soil: A Review

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Abstract
Rice (Oryza sativa L.) is one of the most important stable food crops in the world. Exploiting the production potential of high yielding rice varieties through agronomic management is one of the alternatives to feed the ever growing population. For this, fertilizers from different sources have contributed substantially to the spectacular increase in rice yield and to improve soil properties. The objective of this paper is to comprehensively review the literatures and recommend the best proportion different source of fertilizers for sustainable rice production and soil properties improvement. Different original research articles published elsewhere in the world were reviewed to compile the information. Rice yield and yield contributing traits significantly increased with the use of compost, vermin compost sasbania, green manure and FYM in combination with chemical fertilizer than individual sources in most of the findings. Higher total nutrient uptake by rice crop was also recorded under integrated nutrient source. Moreover integrated application of inorganic and organic fertilizers helped in increasing the availability of nutrients and improves major physical and chemical characteristics of the soil. In conclusion, application of 50 % fertilizers from organic sources and 50 % from inorganic sources is the best combination and reported by many scientists for rice yield and soil properties improvement.
Keywords: NPK, compost, green manure, farm yard manure, sasbania

Introduction

Rice (*Oryza sativa L.*) is one of the most important stable food crops in the world. It is the major source of calories for 40 percent of the world population (Virdia and Mehta, 2009). Currently, the world population is increasing at alarming rate but there is no scope to increase the net cultivable land for crop production. Exploiting the production potential of high yielding rice varieties through agronomic management is one of the alternatives to feed the ever rising population. For this, fertilizers have contributed substantially to the spectacular increase in rice yield. However, growing crop with indiscriminate use of fertilizers has resulted into degradation of lands owing to low yields with poor quality of produce.

The use of inorganic fertilizer to sustain cropping was found to increase yield only for some few years but on long-term, it has not be effective and leads to soil degradation (Satyanarayana *et al.,* 2002). On the other hand, continuous application of organic fertilizer alone on rice field resulting low yield and low N and K content at the mid-tillering stage of rice plant (Javier *et al.*, 2004). This implies that the need of integrated nutrient management for rice production. Therefore the combined use of organic manures and inorganic fertilizers help in maintaining yield stability through correction of marginal deficiencies of secondary and micronutrients, enhancing efficiency of applied nutrients and providing favorable soil physical conditions (Gill and Walia, 2014).

Integrating nutrient management (INM) aims for efficient and judicious use of all the major sources of plant nutrients in an integrated manner (Farouque and Takeya, 2007). The major components of INM system are fertilizers, farmyard manure/compost, green manure, crop residues/recyclable wastes and bio fertilizers. Hence, the objective of this paper is to comprehensively review the literatures and recommend the best proportion of organic and inorganic source of fertilizers in integrated nutrient management system for sustainable rice production and soil improvements

1. Materials and Methods

To compile the information on integrated nutrient management different original research articles that are published elsewhere in the world were reviewed.

2. Results and Discussions

2.1. Effects of Integrated Nutrient Management on Rice Yield and Yield Attributes

An integration of available farm manures (compost, sasbania green manure and farm yard manure) with mineral fertilizer resulted in significant increases in paddy grain yield and yield attributes (Sarwar *et al.,* 2008; Buri *et al.,* 2012). Higher tiller number plant^{-1}, paddy and straw yield of rice were recorded where 20 t ha^{-1} green manure(GM) plus 150-100-100 kg ha^{-1} NPK were applied than the individual source of fertilizers (Ahmad *et al.,* 2001). Yadav *et al.* (2005) further reported that rice yield was maximum with 25% N substitution through green leaf manure + 100% NPK fertilizer in rice-wheat cropping system. Mehedi *et al.* (2011) further conclude that sesbania at 20 t ha^{-1} + 75% recommended dose of chemical fertilizer proved to be the best combination to get reasonable yield.

Greater tiller number, filled grains per panicles , 1000-grain weight and an optimum yield of rice was obtained by application of 120: 60: 45 kg N: P_2O_5:K_2O ha^{-1} in combination with farm yard manure than the individual sources of NPK and control (Satyanarayana *et al.,* 2002). Further investigation by Sharma (2013) indicated that the growth, development, yield attributes of rice was found to be best when 50% N through farm yard manure and 50% NPK was applied in rice-wheat cropping system. Moreover Ali *et al.* (2009) reported that significantly highest grain and straw yield of rice (5.52 t ha^{-1} and 6.73 t ha^{-1} respectively) was obtained in 70% of recommended dose of chemical fertilizers and 3 tones poultry manure ha^{-1} than 70% NPKS alone and the control. Moreover Khan *et al*. (2007) observed the combined fertilizer application of NPK: GM: Zn (soil application) at a rate of 120-90-60 kg ha^{-1}: 10 t ha^{-1}: 10kg ha^{-1} gave significantly maximum plant height, number of tillers, number of panicles, number of spikelets, 1000 grain weight, yield and straw yield of paddy rice as compared to NPK alone and the control (Table 1).

Table 1: Effect of Organic and Inorganic Fertilizers on Different Growth and Yield Parameters of Rice

Treatment	Plant Height (cm)	Tillers m^{-2}	Panicles m^{-2}	Spikelet $Panicle^{-1}$	1000 paddy Wt.(g)	Paddy yield $t.ha^{-1}$	Straw yield $t.ha^{-1}$
Control	68.67^{e}	181.7^{e}	177.3^{e}	97.7^{e}	18.17^{d}	4.70^{d}	8.82^{d}
NPK alone	76.30^{d}	272.7^{d}	268.7^{d}	110.8^{d}	19.90^{cd}	5.76^{c}	11.13^{bc}
NPK+FYM	88.73^{abc}	283.0^{cd}	279.3^{c}	116.8^{bcd}	22.33^{abc}	6.64^{b}	11.20^{bc}
NPK+GM	90.53^{abc}	294.0^{bc}	289.3^{b}	116.9^{bcd}	21.83^{abc}	6.41^{b}	11.30^{bc}
NPK+Zn(SA)	85.93^{bc}	275.0^{d}	271.0^{cd}	116.0^{bcd}	20.17^{bcd}	6.51^{b}	11.03^{bc}
NPK+FYM+Zn(SA)	89.27^{abc}	306.0^{ab}	301.3^{a}	116.2^{bcd}	22.83^{abc}	7.26^{a}	13.3^{a}
NPK+GM+Zn(SA)	93.53^{a}	315.0^{a}	309.3^{a}	136.5^{a}	23.50^{a}	7.32^{a}	13.93^{a}
NPK+Zn(RD)	85.00^{c}	284.7^{cd}	268.3^{d}	112.1^{cd}	20.90^{bcd}	6.30^{b}	10.6^{c}
NPK+FYM+Zn(RD)	89.4^{abc}	306.3^{ab}	301.3^{a}	121.9^{bc}	22.83^{abc}	7.24^{a}	13.2^{a}
NPK+GM+Zn(RD)	92.67^{ab}	305.3^{ab}	307.0^{a}	125.9^{b}	23.17^{ab}	7.25^{a}	13.2^{a}
LSD 0.05	7.577	13.53	9.109	10.47	3.029	0.3639	1.625

Values followed by the same letter(s) in each column are not significantly different at 5 % level of probability.
Note :Rate of NPK= 120-90-60 kg ha^{-1}, FYM=10 t ha^{-1}, GM=10 t ha^{-1}, Zn (SA) = 10kg ha^{-1} in the form of ZnSO4 fertilizer, Zn (RD) =1.0% in $ZnSO4^{-1}$ (A.R) solution and dipping for 5 minutes. Where NPK:Nitrogen, Phosphorus and Potassium respectively;FYM:Farm Yard Manure;GM:GreenManure; Zn:Zink; SA:Soil Application; RD:Root Dipping;
Source: Khan *et al*. (2007)

Significant increase in grain yield of rice by 10.9, 21.8 and 28.5 % with the conjunctive use of farm yard manure, vermicompost and poultry manure with NPK respectively compared to no manure treatment and NPK alone was reported by Khursheed *et al.* (2013). In other studies application of two-thirds of the recommended dose of nitrogen plus some organic fertilizer, either farm yard manure or rice straw compost at a rate of 7 t ha^{-1} and 5 t ha^{-1} respectively, resulting in higher dry matter production, better leaf area index of rice under saline soil conditions **(**Zayed *et al.,* 2013). Besides, treatment receiving 50% recommended fertilizer dose + residual effect of cow dung 2.5 t ha^{-1}, poultry manure 1.5 t ha^{-1} and compost 2.5 t ha^{-1}) produced the highest grain yield (6.87 t ha^{-1}) and straw yield (7.24 t ha^{-1}) as compared to the individual treatments as well as the control (Liza *et al.,* 2014).

According to Sarwar (2005), the combination of compost with chemical fertilizer further enhanced the biomass and grain yield of rice crops under rice-wheat cropping systems. Further studies by Ranjitha *et al.* (2013) indicated that significantly maximum grain and straw yield of rice was recorded with the application of 50 % recommended dose of nitrogen through urea + 50 % recommended dose of nitrogen through vermicompost . It was also noticed that straw yield of rice was 3.7, 15.9 and 20.7 % higher when NPK applied with farm yard manure, vermicompost and poultry manure, respectively as compared to NPK alone (Khursheed *et al.,* 2013). Larijani and Hoseini (2012) also found that more tiller number (28%), more panicle/m^2 (60%), number of filled grains/m^2 (20.6%), spikelet per panicle (19.6%) and more grain yield (30.6%) with combined use of organic and chemical fertilizer compared with chemical fertilizer alone (Table 2).

Table 2: Mean comparison of plant height, yield and yield components of different treatment

Treatment	Plant height (cm)	Tiller number Plant^{-1}	No.of panicle m^{-2}	No.of spiklet panicle $^{-1}$	No.of filled grain panicle $^{-1}$	1000 grain weight(g)	Grain yield (kg ha^{-1})
SRI_1	138.1^{abc}	10.8^{a}	182.3^{b}	108.5^{abc}	84.2^{a}	25.1^{a}	3978.4^{ab}
SRI_2	129.2^{c}	13.6^{a}	170.0^{b}	97.2^{bc}	84.8^{a}	25.7^{a}	3360.0^{b}
SRI_3	132.4^{c}	10.7^{a}	166.3^{b}	94.1^{c}	66.5^{b}	23.8^{a}	3670.8^{ab}
SRI_4	134.3^{bc}	11.2^{a}	175.0^{b}	105.0^{abc}	81.6^{ab}	24.0^{a}	3855.2^{ab}
SRI_5	141,4^{abc}	17.4^{a}	236.7^{a}	97.3b^{c}	85.4^{a}	24.4^{a}	3737.0^{ab}
SRI_6	138.1^{abc}	16.9^{a}	249.0^{a}	97.6^{bc}	81.1^{ab}	24.4^{a}	4772.4^{a}
SRI_7	149.8^{a}	16.4^{a}	220.0^{a}	114.4^{ab}	95.4^{a}	24.9^{a}	4567.8^{ab}
SRI_8	148.2^{a}	16.3^{a}	221.3^{a}	120.7^{a}	86.1^{a}	24.0^{a}	4382.2^{ab}
SRI_9	146.8^{ab}	13.6^{a}	155.3^{b}	100.9^{bc}	79.1^{ab}	24.9^{a}	3652.6^{ab}

Means with similar small letters within the column, are not significantly difference ($p<0.05$) by Duncan methods.

Note: *SRI1: Azola compost application 6 ton ha^{-1}as basal without chemical fertilizer;SRI2: Organic fertilizer, Biol555 with amount of 1 ton ha^{-1} without any chemical fertilizer;SRI3: Azola compost (6 ton ha^{-1}) + urea application 50 kg ha as basal; SRI4: Biol555 (1 ton ha^{-1})+ urea application 50 kg ha as basal; SRI5: Azola compost (6 ton ha^{-1}) + Urea application 50 kg ha^{-1} (25% as basal and 25% at PI); SRI6: Biol555 (1 ton ha-1)+ Urea application 50 kg ha-1(25% as basal and 25% at PI); SRI7: Azola compost (6 ton ha-1) + Urea application 100 kg ha-1 (50% Urea as basal and 25% at early tillering and 25% at PI); SRI8: Biol555 (1 ton ha^{-1})+ Urea application 100 kg ha^{-1}(50% Urea as basal and 25% at early tillering and 25% at PI); SRI9: Recommended SRI techniques with NPK application using urea, Triple super phosphate and potassium sulfate (100-100-100 kg ha^{-1} as basal) without compost and organic fertilizer.*

Source: Larijani and Hoseini (2012)

Application of 100 % recommended dose of nitrogen from urea significantly influenced the yield of rice in 1st year of experiment but during the 2nd year of experiment application of 50 % recommended dose of nitrogen from vermicompost and the rest through chemical fertilizer (urea) produced significantly highest grain and straw yield of rice in rice-wheat cropping system (Koushal *et al.,* 2011). It has been also reported that application of 125% RDF + 5 t ha^{-1} vermicompost was increased the number of panicles (20.50%), panicle length (23.12%), panicle weight (13.02%), 1000 grain weight (12.90%), grain yield (31.15%) and straw yield (37.12%) over the control and the individual nutrient sources (Kumar *et al.,* 2014). Moreover, the mean grain yield of rice for the three years showed that significantly higher rice yields than the other treatments at 4.0 t ha^{-1} PM + 30 kg N ha^{-1} and 2.0 t ha^{-1} PM + 22.5-15-15 kg N: P_2O_5: K_2O ha^{-1}(Issaka *et al.*, 2014). Saba *et al.* (2013) further noticed that combination of bio-fertilizer, nitrogen and phosphorous (500: 120: 90 kg ha^{-1}) exceeded all other treatments including P and N alone in number of tillers m^{-2}, number of panicles m^{-2}, number of spikelets panicles^{-1}, percent normal kernels, 1000-grain weight (g) and paddy yield (t ha^{-1}).

2.2. Effects of Integrated Nutrient Management on Rice Nutrient Uptake

Nutrient uptake by rice crop is also influenced by integrated nutrient management (INM) practices. Virdia and Mehta (2009) studied that the pooled result of nutrient uptake and they found that the application of organic fertilizer along with recommended dose of fertilizer (RDF) gave numerically higher uptake value of N.P.K. than only RDF treatment in grain, straw and total uptake. Studies by Zayed *et al* .(2013) also proved that application of two-thirds of the RDN plus some organic fertilizer, either FYM or rice straw compost at a rate of 7 t ha^{-1} and 5 t ha^{-1} respectively, resulting in higher plant nitrogen and phosphorus content even under saline soil conditions of rice field**.** Ranjitha *et al*. (2013) also disclosed that significantly maximum NPK uptake by rice @ 157.9-30.7-166.0 kg ha^{-1} was obtained in treatments receiving 50% inorganic nitrogen source (root dipping) and 50% organic nitrogen source through vermicompost (root dipping) as compared to 100% inorganic N source alone (136.5-23.2-125.6 kg ha^{-1}) and control (58.7-6.9-61.6 kg ha^{-1}).

Sathish *et al.* (2011) also reported that treatments which received combination of organic and inorganic fertilizer showed higher uptake values by rice crop of all the three nutrients NPK (Table-3).

Table 3: Uptake of NPK by rice at harvest under integrated nutrient management in rice- maize sequence (1988 & 2006)

Treatments	N uptake (kg/ha)		P uptake (kg/ha)		K uptake (kg/ha)	
	1989	2006	1989	2006	1989	2006
Control	45.90	64.19	6.90	15.68	59.30	13.29
25 %NPK	49.50	89.28	11.30	20.63	64.80	25.69
50%NPK	65.40	70.50	9.60	18.53	65.40	14.68
75%NPK	70.90	72.67	8.40	21.61	69.00	18.96
100%NPK	78.80	97.28	7.60	23.51	69.80	23.38
50%NPK+50% N(FYM)	64.00	80.56	7.20	20.34	70.70	19.84
75%NPK+25%N (FYM)	67.90	83.33	15.70	21.90	98.20	17.52
50% NPK + 50% N (Paddy Straw)	60.90	82.66	7.80	19.68	67.50	18.99
75% NPK + 25% N (Paddy Straw)	78.90	97.34	9.10	21.85	75.00	22.47
50% NPK + 50% N (Glyricidia)	81.70	87.16	9.40	23.65	97.80	20.92
75% NPK + 25% N (Glyricidia)	71.10	92.09	9.80	29.13	92.30	25.54
(85:50:30 kg NPK/ha & FYM 2 t/ha)	68.80	79.69	10.50	16.99	66.50	16.89
SEm+_	1.111	3.82	0.263	0.95	0.644	0.96
CD@5%	3.204	11.00	0.759	2.73	1.857	2.78

Source; Sathish *et al.* (2011)

Rani and Sukumari (2013) also observed that higher total N, P, K, Fe, Mn and Zn uptake by medicinal rice (Njavara) was recorded under integrated nutrient source than the individual organic and inorganic sources. Moreover Kumar *et al*. (2014) proved that application of organic and inorganic sources of nutrient in combination remarkably increased N uptake in grain (36.81%) and straw (42.81%), P uptake in grain (32.62%) and straw (31.56%) and K uptake in grain (35.46%) and straw (25.39%) over control (Table 4).

Table 4: Effect of organic and inorganic sources of nutrient on N, P and K uptake of rice Sources

Treatment	Nitrogen uptake (kg/ha)		Phosphorus uptake (kg/ha)		Potassium uptake (Kg/ha)	
	Grain	Straw	Grain	Straw	Grain	Straw
Control	43.38	27.00	6.56	7.32	14.24	100.45
75 % RDF	45.19	27.25	7.02	7.53	15.28	102.18
100 % RDF	47.30	27.82	7.30	7.90	15.34	102.53
125 % RDF	48.39	28.31	7.41	8.03	16.13	104.29
2.5 t/ha vermicompost	48.32	27.55	7.35	7.95	15.86	103.43
5 t/ha vermicompost	49.56	29.71	7.42	8.19	16.72	104.58
75% RDF + 2.5 t/ha vermicompost	50.39	27.79	7.63	8.20	17.24	106.26
100 % RDF + 2.5 t/ha vermicompost	50.65	30.15	7.88	8.57	17.44	108.35
125 % RDF +2.5 t/ha vermicompost	51.33	30.56	8.06	8.60	17.78	110.45
75% RDF + 5 t/ha vermicompost	53.70	33.15	8.46	9.05	18.20	110.70
100 % RDF + 5 t/ha vermicompost	54.46	34.52	8.69	9.09	19.23	114.97
125 % RDF + 5 t/ha vermicompost	59.35	38.56	8.70	9.63	19.29	125.95
SEm*	1.9	0.6	0.3	0.3	0.8	4.7
CD(p=0.05)	6.1	2	0.9	1.0	2.5	14.9

Sources: Kumar *et al.* (2014)

Mehedi *et al.* (2011) also reported that maximum contents of NPK both in paddy and straw of rice were recorded in the combination of Sesbania at 20 ton ha^{-1} + 75% recommended dose(RD) and least in FYM alone at 20 ton ha^{-1} in rice-wheat cropping system. It has been further reported that the integrate application of Dhaincha, mung bean residue, CD or PM with 70% NPKS resulted in considerable higher uptake of nutrients by the crops compared to 70% NPKS application (Ali *et al*., 2012).Yadav *et al.* (2005) further reported that the NPK uptake in rice was higher with 100% NPK and in the treatments with 50 or 25% NPK substitution through green leaf manure (GLM) in rice-wheat cropping system. Moreover, the total uptake of N, P, K and Zn by rice crop increased significantly with the application of NPK fertilizers or their combined use with organic manures such as green-manure, FYM and cut rice straw in rice-wheat cropping sequence (Vinay, 2006).

2.3. Effects of Integrated Nutrient Management on Some Physico-Chemical Properties of Soil

Integrated application of inorganic fertilizers and organic manures with micronutrients helped in increasing the availability of nutrients and in sustaining and restoring soil fertility in its available nutrients and major physical and chemical characteristics of the soil (Singhl *et al.,* 2011). Similarly, the combined application of FYM and inorganic N and P fertilizers improved the chemical and physical properties, which may lead to enhanced and sustainable production of rice (Tilahun *et al.*, 2013). Moreover the higher yield and yield attributes of rice with combined use of nutrients as compared to 50% RDF through inorganic fertilizers or 100% RDN through FYM could be attributed to integrated effect on all physico-chemical properties as well as available nutrients status of soil that facilitated in maintaining better soil physical condition and continuous supply of nutrients throughout the crop growth (Singh *et al.,* 2012).

Dubey *et al.* (2014) proved that the bulk density of soil and available P and K contents almost maintained their parental status after completion of fourth crop cycle under 100% organics and integrated nutrient management, while 100% inorganic exhibited declining trend in P and K as well as rising trend in bulk density. Moreover, the combination of compost, green manure, wheat cut straw and farm yard manure along with chemical fertilizers improves the physical properties of soil like water holding capacity, infiltration rate, available soil moisture, liable C and microbial count, penetration resistance and reduces bulk density, soil strength in rice-wheat cropping system (Walia *et al.,* 2010). In other findings physical properties of a saline-sodic soil like bulk density, porosity, void ratio, water permeability and hydraulic conductivity were significantly improved when FYM (10 t ha^{-1}) was applied in combination with chemical amendments (Hussain *et al.,* 2001).

The increment of organic carbon, available P_2O_5 and K_2O content in soil were observed when compared with the initial values in all integrated nutrient sources except in treatment receiving only RDF (Virdia and Mehta, 2009). Sarwar *et al.* (2008) noticed that application of higher level of compost alone and in combination with chemical fertilizer in the same level reduced the soil pH and sodium absorption ratio; increasing electrical conductivity, available phosphorus, water soluble K and organic matter status of soil significantly, as compared to control as well as chemical fertilizer alone after harvesting of rice and in rice-wheat cropping system (Table 5).

Table 5: Variations in soil PHs, ECe, SAR, soil organic matter, available P and water soluble K after the harvest of rice as affected by different levels of compost and chemical fertilizer in normal soil

	After rice harvest					
Treatments	**PHs**	**ECe dsm^{-1}**	**SAR $(mmol^{-1})^{1/2}$**	**Organic matter (%)**	**Available P $mgkg^{-1}$**	**Water soluble K ($mmolcL^{-1}$)**
Control	8.2^{A}	2.4^{C}	6.5^{A}	0.56^{F}	5.72^{E}	0.57^{F}
Recommended fertilizer	8.1^{A}	2.5^{C}	3.6^{B}	0.74^{E}	13.01^{D}	1.42^{D}
Compost 12 t ha^{-1}	7.8^{B}	2.9^{AB}	3.8^{B}	0.85^{D}	13.51^{D}	1.26^{E}
Compost 24 t ha^{-1}	7.8^{B}	3.2^{A}	3.0^{B}	0.89^{C}	16.18^{C}	1.89^{B}
Compost 12 t ha^{-1} + fertilizer	7.8^{B}	2.6^{BC}	3.3^{B}	0.93^{B}	18.34^{B}	1.67^{C}
Compost 24 t ha^{-1} + fertilizer	7.8^{B}	3.0^{A}	4.8^{AB}	0.98^{A}	27.55^{A}	2.29^{A}

Values followed by the same letter(s) in each column are not significantly different at 5 % level of probability.
Sources: Sarwar *et al.* (2008)

Nyalemegbe *et al*. (2009) showed that cow dung and poultry manure applied at half their recommended rates, i.e. 10 t ha^{-1} CD plus 45 kg N ha^{-1} urea and 10 t ha^{-1} PM plus 60 kg N ha^{-1} urea enhanced soil physical properties (particularly under upland condition) and soil fertility as well as bring about low soil pH/redox potential as compared with the recommended inorganic nitrogen fertilizer level of 90 kg N ha^{-1}. It is evident from the study that application of vermicompost and biofertilizer in integration with NPK helped in increasing organic carbon, available N, available P, available K and available micronutrient status in soil than RD of NPK alone. Sarwar (2005) also reported that a slight increase in electrical conductivity (ECe) of normal soil and ECe of saline sodic soil decreased in combined application of organic manure and gypsum due to the leaching of salts as a result of improved soil physical conditions.

Walia *et al.* (2010) observed that the integrated nutrient management technique resulted in a positive influx of nutrients by increasing organic carbon content, available nitrogen, phosphorus and potassium varying from 0.390 to 0.543%, 171.7 to 219.3 kg ha^{-1} and 20.5 to 43.3kg ha^{-1} respectively. Besides, composts of pea plant residue (PP) with dried chicken manure (CM) and CM plus rapeseed oil residue enriched soil with N, P, K and other nutrients, and increased nutrient uptake in wheat – rice cropping system (Zia *et al.,* 2008). Further application of FYM and cut rice straw as well as green-manuring in rice and wheat significantly improved the available N, P, K and Zn status of the soil (Vinay, 2006). Similarly the application of N at 90 kg level as 50% through rice straw cut + 50% N as poultry manure registered higher available N, P and K contents of soil during different growth stages as compared to the other treatment combinations including recommended NPK fertilizers (Krishnakumar and Haefele, 2013). In another finding the highest available soil phosphorus after rice harvest was realized with the combined application of 15 t ha^{-1} FYM and 100 kg ha^{-1} P (Tilahun *et al.*, 2013).

3. Conclusion

In conclusion, most of the findings revealed that some valuable benefits of integrated nutrient management over sole application of the individual fertilizer sources in improving yield and nutrient uptake and physico-chemical properties of the soil in rice based cropping system. In association with this, most of the scientist concluded that 50% from organic sources and 50% from inorganic sources is the best combination in rice based cropping system to improve soil physico-chemical properties, yield and nutrient uptake capacity of rice.

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