Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.6181

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **6 (1):** 356-367 (2018)

Research Article

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Ameliorating effects of nutrient management on different form of nitrogen and Nutrient Use efficiency in Chambal Ravine of Madhya Pradesh

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Received: 5.01.2018 | Revised: 10.02.2018 | Accepted: 14.02.2018

ABSTRACT

A field experiment was conducted at degraded ravine land to evaluate the influence of inorganic and organic sources of plant nutrients practices on the different form of nitrogen. It was observed that the Total Soil Nitrogen (0.077 %), Ammonical-N (33.81 mg kg^{-1}), Nitrate-N (25.49 mg kg^{-1}) and Available-N (168.30 Kg ha^{-1}) highest in 75% RDF+2.5 ton FYM ha^{-1}+PSB+ZnSO$_4$@25 kg ha^{-1}(T$_6$), under nutrient management practices viz., seven treatments Farmer Practices (T$_1$), 100% RDF (T$_2$), 150% RDF (T$_3$), STCR Based NPK Application (T$_4$), 50% RDF+5 tone FYM ha^{-1} + PSB+ ZnSO$_4$@ 25 kg ha^{-1} (T$_5$), 75% RDF+2.5 ton FYM ha^{-1}+ PSB+ ZnSO$_4$@ 25 kg ha^{-1} (T$_6$), Organics Practices FYM @10tone ha^{-1}+PSB+Azotobactor (T$_7$), in randomized block design, replicated three times. Maximum N and P use efficiency (67.68% and 23.75%) was recorded under application of FYM @10 ton ha^{-1} +PSB + Azotobacter and K use efficiency (35.41% under 50% RDF+5 tone FYM ha^{-1} + PSB+ ZnSO$_4$@ 25 kg ha^{-1} practices in pooled basis, respectively. The highest nitrogen gain in the treatment T$_2$ followed by T$_6$ & T$_3$, while there was a gain in the case of T$_7$ and T$_1$. Maximum depletion in phosphorus was recorded in T$_6$ and followed by T$_1$, T$_2$ and T$_3$ during both the years. In case of potassium maximum reduction was recorded in the treatment T$_6$ which was very closely followed by T$_3$ and T$_7$ and minimum was in the treatment T$_4$. The straw yield (4454.27 kg ha-^{1}) and seed yield (3984.45 kg ha-^{1}) of wheat was found highest in 75% RDF+2.5 ton FYM/ha+ PSB+ ZnSO$_4$@ 25 kg ha^{-1} (T$_6$) practices followed by 150% RDF and STCR Based NPK Application (T$_4$), Thus, the study demonstrated that the 75% RDF+2.5 ton FYM ha^{-1}+ PSB+ ZnSO$_4$@ 25 kg ha^{-1} (T$_6$), practices improved nutrient management and performance of wheat crop.

Key words: *Chambal ravine, Different form of Nitrogen, Nutrient Management, Wheat*

INTRODUCTION

Nitrogen is inorganic and organic forms in soils. Over 90 percent of soil N is associated with soil organic matter. Nitrogen is in compounds identifiable as part of the original organic material such as proteins, amino acids, or amino sugars, or in very complex unidentified substances in advanced stages of decomposition.

Cite this article: Argal, M.S., Verma, S.K. and Rajput, S., Ameliorating effects of nutrient management on different form of nitrogen and Nutrient Use efficiency in Chambal Ravine of Madhya Pradesh, *Int. J. Pure App. Biosci.* **6(1):** 356-367 (2018). doi: http://dx.doi.org/10.18782/2320-7051.6181

These uncharacterized substances resist further microbial degradation and account for the very slow availability of soil N. Plants may use either ammonium (NH_4+), or nitrate (NO_3-) which be have quite differently in soils. Positively charged NH4+ is attracted to negatively charged sites on soil particles as are other cations. It is available to plants, but the electrostatic attraction protects it from leaching. Conversely, negatively charged NO_3- does not react with the predominately negatively charged soil particles, so it remains in the soil solution and moves with soil water. Therefore NO_3- may leach out of the root zone when rainfall is excessive, or accumulate at the soil surface when conditions are dry. Conducted three incubation experiments to determine the influence of sludge rate, N addition, salinity, and wetting and drying cycles on different N forms in sludge-amended calcereous silt loam soil. The rate of sludge as well as N was found to significantly affect NO^{3-} N accumulation. The cumulative inorganic N at the end of 12 weeks incubation was dependent on sludge rate and slightly affected by N addition. Cumulative mineralized N at 0, 40, 80, and 160 t ha^{-1} sludge treatments were 15.4. 83.7, 105.1, and 165.0 mg kg^{-1} soil, respectively. In case of sludge and N addition, these figures were 10.2, 99.6, 108.4, and 180.4 mg kg^{-1} soil. N mineralization rate constant K increased from 0.214 in the control to 0.303, and 0.439, then decreased to 0.309 $week^{-1}$ in soil treated with 0, 40, 80, and 160 t ha^{-1} sludge, respectively. Mean K values decreased with N addition and when excluding inorganic N found in soil and sludge at the start. Nitrogen mineralization potential N_0 values greatly increased with sludge and N addition. A salt mixture of (1:1 NaCl:$CaCl_2$) at a concentration of 7.5 mg g‘^{1} soil delayed nitrification in unmended soil, while 15 mg g^{-1} caused complete inhibition. In sludge treated soil, retardation and complete inhibition of nitrification occurred at 7.5 and 60 mg g^{-1} salt mixture, respectively. Complete inhibition of ammonification occurred at salt mixture of 30 mg g^{-1} soil. Drying of either control or amended soil led to a marked drop in NH^{4+} -N and NO^{2-} + NO^{3-} -N content of soil. Both NH^{4+} N and NO^{2-} + NO^{3-} -N increased during wetting cycles. Mineralization was greater after 4 cycles of wetting and drying than after the first cycle finding of Abdel *et al* [1]. Out of 328.0 million ha geographical area of the country, nearly 147.75 million ha is subjected to various types of degrees of degradation. Of this about 93.68 million ha is severely eroded [19]. Out of estimated 20.06 lakh ha area under ravines in the country, about 6.83 lakh ha is in Madhya Pradesh. And out of that, nearly 5.7 lakh ha is in Chambal and Gwalior divisions of the state, indicating that the Chambal basin suffers most severely from the problem of land degradation due to ravine formation. The Government of Madhya Pradesh has tried to check this soil erosion and expansion of ravines by the means of watershed development and by aerial-seeding for plants like ProsopisAcacia, and Jatropha in the ravines. But the rugged terrain is still stubborn andonce a dacoit sanctuary, these ravines now play host to tourists with a flavour for adventure. Ravines are a considerable extent of area affected by ravines, mostly along the banks of river Chambal, Kalisindh and their tributaries. Out of the 0.72 m ha of Chambal command area, about 0.224 m ha land has been converted into ravines. Sebastian [29] reported that there have been programmes galore in the past for reclamation of ravines in the troubled intersection of Madhya Pradesh, Rajasthan and Uttar Pradesh, however, nothing has worked. Jha[10] reported that a series of ravine reclamation and soil erosion control schemes launched from time to time by the central and state governments – such as the Ravine Erosion Control Scheme, the various afforestation programmes and the Dacoit Prone Area Development Programme have not helped. Ravine is described as a “Cancer of the Land” and is the severest form of erosion. Potentially, the table lands of this area are highly productive under better managed conditions. The climate and the quality of soil and water are good. The area is free from major insect pest and diseases of the crops. Thus, if properly managed these ravines can be converted into lush green areas providing better food, fodder, fuel wood and fibre resulting into better socio economic environment to the people of the ravines. The changing scenario in agriculture and escalating land prices are compelling to villagers/ farmers to utilize the waste land around their vicinity for crop production. The input cost incurred to level the ravine land (Rs./ha) is very less as compared to agricultural land cost. The ravenous land are most fragile in nature and need special care like conservation practices, nutrient management, cropping sequences and justified land use for its potential production.

MATERIALS AND METHODS

The field experiment was conducted during two consecutive *rabi* seasons of 2013-14 and 2014-15 at Aisah (Ambah) Tehsil, district Morena, on Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya farm situated in the ravines of Chambal river situated in Grid zone lying in between 26^{o} 41' 02.60" N latitude and 78° 06' 30.20″ E longitude with an altitude of 163 meters from mean sea level (MSL). The region experiences subtropical climate where hot winds during summer flow for a greater part of the day and night temperatures remain high. The hottest months are May and June (mercury touches 48°C), and the temperature drops considerably in last week of June. The winter commences in October and the months of December and January is the coldest, the minimum temperature some time touches to the freezing point at night. Winter rains are erratic and irregular. The average annual rainfall of the Chambal division is 891.4 mm and a major portion is received in July, August and September. The weather remains sultry and humid in most of the months during the year. The soil of experimental site is sandy loam in texture (inceptisols), low in organic carbon, highly alkaline and saline with low available nitrogen (N), medium phosphorous (P) and high potassium (K) contents. The experiment consists of seven treatments viz., Farmer Practices T_1, 100% RDF (T_2), 150% RDF (T_3), STCR Based NPK Application (T_4), -50% RDF+5 tone FYM + PSB+ $ZnSO_4$@ 25 kg ha^{-1}(T_5), 75% RDF+2.5 ton FYM ha^{-1}+ PSB+ $ZnSO_4$@ 25 kg ha^{-1} (T_6), Organics Practices FYM @10 tone ha^{-1}+PSB+Azotobactor (T_7), with the crop cultivar MP-1203 of wheat in randomized block design, replicated three times. The recommended fertilizer dose for wheat as per the treatments were applied (120:60:40 N, P_2O_5 and K_2O kg ha^{-1}, respectively) in the form of urea, single superphosphate and muriate of potash, 5cm away from the seed line and 5 cm deep in the soil. In all, 50 percent of nitrogen and entire dose of P_2O_5 and K_2O was applied at the time of sowing and remaining 50 per cent of nitrogen was top dressed in the form of urea in two splits for wheat at 30 and 50 days after sowing. Wheat was sown at a spacing of 22.5X5 cm in the second week of November and harvested in the second week of March. The data was analyzed statistically and treatment means were compared using LSD techniques at 5% probability appropriate for RBD by Gomez and Gomez [35]. Soil samples were collected at harvest (October 2013 and 2014) from soil 0-15 cm from three spots in each plot. Composite soil samples of each replication from the experimental site were collected, processed to pass through 2 mm sieve and preserved for further analysis. Similarly, representative soil samples from each plot were collected after the harvest of previous crop under the experimental period November 2013 to March 2014. The soil samples were dried in shade, processed to pass through 2 mm sieve and used for further analysis.

Nutrient Use Efficiency: Nutrient use efficiency (kg ha^{-1}) = GY / N Applied. Where, GY = grain yield (kg ha^{-1}), N = supply in (kg ha^{-1}).

Balance Sheet of Nutrient: The soil nutrient balance sheet was prepared by calculating total available nutrient and difference due to crop removal. (Initial soil nutrient status+ Nutrient added crop)- (Crop removed through uptake).

Mineral N (NH_4^+-N and NO_3^- -N) determination in soil: The Amonical and Nitrate- form of nitrogen in soil was estimated by the method described by Bremner and Keeney [4].

Available nitrogen: Available nitrogen was estimated by alkaline $KMnO_4$ method where the organic matter in soil was oxidized with hot alkaline $KMnO_4$ solution. The ammonia (NH_3) evolved during oxidation was distilled and trapped in boric acid mixed indicator solution. The amount of NH_3 trapped was estimated by titrating with standard acid by Subbiah and Asija[33].

Total Nitrogen: Total nitrogen content in soil was estimated by the micro-Kjeldahl method according to Bremner and Mulvaney[5]. In this method digested soil sample used with concentrated sulphuric acid (H_2SO_4) in a digestion tube. The results were computed and expressed in percentage.

RESULTS AND DISCUSSION

Nutrient Use Efficiency: The data computed for nutrient use efficiency (%) of N, P and K are presented in table 2. In case of N, the maximum N use efficiency (73.76%, 61.59% and 67.68%) was recorded under application of FYM @10 ton ha^{-1} +PSB + Azotobacter in 2013 - 14, 2014 - 15 and pooled basis, respectively. Lowest N recovery was recorded with treatment T_6 (FYM 10 t ha^{-1}) during both the years and pooled basis. Revealed that nutrient use efficiency of P varied in range from 8.32% to 21.49% and 8.35% to 26.02% in 2013 - 14 and 2014 - 15, respectively. The highest apparent recovery of P was registered with treatment T_7 followed by T_5 while lowest was noted from treatment T_6 during both the years. Maximum nutrient use efficiency of K was observed under 50% RDF+5 ton FYM ha^{-1} + PSB+ $ZnSo_4$ 25 kg ha^{-1} during both the years and it was closely followed by treatment T_6. The minimum value of nutrient use efficiency of K was recorded with treatments T_2 during both the years. This high N and P uptake efficiency in organic wheat crops was mainly attributable to the low soil fertility of organic fields, as wheat biomass production was 1.44 times greater in conventional than organic systems finding of Mulan *et al* [20] and The NUE increases in wheat due to the residual effect of organic manures in addition to the inorganic fertilizers reported by Yaduvanshi *et al*[39]. and Duan *et al*[9]. Results from current study provided the proof that in the current rotation system the $N_{150}N_{150}$ treatment was the best economic treatment for achieving both higher yield and N use efficiency finding of Ping *et al*[23]. In a soil test crop response trial conducted on Mollisol (fine mixed loamy hyperthermic aquic hapludoll) at G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand with wheat (var. UP-2382) and the comparative efficiency of different levels of organic and inorganic nutrients and their impact on yield, uptake and their efficiency have been studied by Bhaduri and Gautam[3]. The effect of fertilizers indicated that grain and straw yields of wheat were increased more prominently with the addition of 150 kg N, 60 kg P_2O_5, 50 kg K_2O and 5 t of FYM ha^{-1}. The same combination of nutrient provided highest nutrient recovery (19.8, 9.9, 24.0%) and return (8.60, 3.23, 8.40 $Rs.Re^{-1}$). However, increased level of N-P_2O_5-K_2O never ensured for increased nutrient efficiency, as they manifested highest value at lowest doses (100 kg N, 30 kg P_2O_5 and 25 kg K_2O ha^{-1}). FYM incorporation along with inorganic nutrients considerably enhanced the yield and nutrient uptake and hence highest nutrient recovery and economic return obtained by application of 5 t of FYM ha^{-1} under INM. Added fertilizer nutrients in combination with organic nutrients showed its positive effect in enhancing the fertilizer use efficiency/recovery and economy. Krobel *et al*[13]. Application of 50% N through FYM + 50% through chemical fertilizers was significantly higher than that under 100% chemical fertilizers applied to both the crops and was on par with 25% N through FYM and 75% through inorganic source. Maximum N, P and K uptake values were recorded when 50% N was substituted by FYM in maize (114.6, 23.9 and 125.5 kg ha^{-1}) and wheat (99.7, 18.1 and 89.8 kg ha^{-1}) and maize-wheat system (214.3, 42.0 and 215.3 kg ha^{-1}) followed by 25% N through FYM and remaining through inorganic source and minimum in control. The productivity, nutrient uptake and per cent response increased with the increase in the fertilizer level but the reverse trend was noted in case of agronomic efficiency and apparent N recovery percent finding by Prasad *et al*[25]. Ying *et al*[40].

Balance sheet of Nutrient: The computed data clearly indicated that maximum quantitative depletion in nutrient content was recorded for potassium in both the years as well as on basis of pooled value, followed by phosphorus and minimum in nitrogen. There was only very marginal reduction in first year (2013-14) and which jumped to very high tune in the second year (2014- 15). Among different treatments there was highest in nitrogen in the treatment T_2 followed by T_6 & T_3, while there was a gain in the case of T_7 and T_1. Maximum depletion in phosphorus was recorded in T_6 and followed by T_1, T_2 and T_3 during both the years. In case of potassium maximum reduction was recorded in the treatment T_6 which was very closely followed by T_3 and T_7 and minimum was in the treatment T_4. Plant nutrient balance and the abundance of Paraglomus drove conventional wheat production, whereas organic production depended mainly on soil moisture, plant nutrient balance, and abundance of Glomus, which was associated with reduced and nutrient-inefficient wheat production finding of Mulan *et al*[20]. The wheat–rice and maize–rice system showed negative K balance of –35.5 and –60.4 kg ha^{-1} in NPK treatment, while potato–rice system showed a positive K balance of 31.0 kg ha^{-1} with NPK treatment. The N, P and K uptake and apparent recovery by the test crops may be used for site-specific nutrient management. The K rates for fertilizer recommendation in wheat and maize in Indo-Gangetic plain need to be revised to take account for the negative K balance in soil finding of Salam *et al*[27]. The net N balance increased with N applied finding of Ping *et al*[23], Sanyal *et al*[28]. and Srinivasarao *et al*[32].

Different forms of Nitrogen : The data indicate that total-N content of the soil under different treatment ranged between 0.047% and 0.093% and significantly greater under 75% RDF+2.5 ton FYM ha^{-1}+PSB+$ZnSO_4$@ 25 kg ha^{-1} (T_6), compared with rest of the treatments. Ammonical- N , Nitrate-N and available-N varied significantly with treatments, being highest 44.18, 43.13 mg kg^{-1}and 175.62 kg ha^{-1} respectively under 75% RDF+2.5 ton FYM ha^{-1}+PSB+$ZnSO_4$@ 25 kg ha^{-1} (T_6) and However, treatment (T_3) 150% RDF, (T_4) NPK application on the basis of STCR equations, (T_5) 50% RDF+5 ton FYM +PSB+ $ZnSO_4$ 25 kg/ha and (T_7) FYM @10 ton/ha+ PSB+ Azotobacter conjoint application of inorganic with organic were at par but lowest (30.23, 1.16 mg kg^{-1} and 108.71 kg ha^{-1} respectively) under farmer practices at during 2013-14. The data indicate total-N content of the soil under different treatment ranged between (0.031% to 0.062%), and significantly greater in 75% RDF+2.5 ton FYM ha^{-1}+PSB+$ZnSO_4$@ 25 kg ha^{-1} (T_6) compared with rest of the treatments. Ammonical- N , Nitrate-N and available-N varied significantly with treatments, being highest 23.44, 7.85 mg kg^{-1}and 160.98 kg ha^{-1} respectively under 75% RDF+2.5 ton FYM ha^{-1}+PSB+$ZnSO_4$@ 25 kg ha^{-1} (T_6) and However, treatment T_5) 50% RDF+5 ton FYM + PSB+ $ZnSO_4$ @25 kg/ha, (T_3) 150% RDF, (T_4) NPK application on the basis of STCR equations, ((T_2) 100% RDF and (T_7) FYM @10 ton/ha+ PSB+ Azotobacter conjoint application of inorganic with organic were at par but lowest 10.17, 2.93 mg kg^{-1} and 84.15 kg ha^{-1} respectively) under farmer practices at during 2014-15. The data on different form of nitrogen the Soil Total-N (%), Ammonical-N (mg kg-^{1}), Nitrate-N (mg kg-^{1}) and available-N (kg ha-^{1}) content in soil on pooled basis in both year. The data indicate total-N content of the soil under different treatment ranged between (0.039% to 0.077%), and significantly greater in 75% RDF+2.5 ton FYM ha^{-1}+PSB+$ZnSO_4$@ 25 kg ha^{-1} (T_6) compared with rest of the treatments. Ammonical- N , Nitrate-N and available-N varied significantly with treatments, being highest (33.81, 25.49 Mg kg^{-1}, 168.30 kg ha^{-1},respectively), under treatment 75% RDF+2.5 ton FYM ha^{-1}+PSB+$ZnSO_4$@ 25 kg ha^{-1} (T_6) and However,

(T_3) 150% RDF, (T_4) NPK application on the basis of STCR equations, (T_5) 50% RDF+5 ton ha^{-1} FYM + PSB+ $ZnSO_4$ @25 kg ha^{-1} and (T_7) FYM @10 ton ha^{-1} + PSB+ Azotobacter conjoint application of inorganic with organic were at par but lowest (20.02, 2.04 Mg kg^{-1}, 96.4 kg ha^{-1}, respectively) under farmer practices, Total and available nitrogen content of soil significantly increases with the application of organic matter in soil. It is well establish fact that the addition of organic matter in soil increase total and available nitrogen in soil. The results confirms the findings of Jha and Rattan[11], Kumar *et al* [14]., Porpavai *et al*[24]. Pawar [22] and Kumar *et al*[15]. Application of organic manures resulted in higher soil organic carbon, available N, P and K than the chemical fertilizers reported by Upadhyay *et al.*[37] and Katkar *et al* [12]. The influence of sludge rate, N addition, salinity, and wetting and drying cycles on different N forms in sludge-amended calcereous silt loam soil. The rate of sludge as well as N was found to significantly affect NO^{3-} N accumulation. The cumulative inorganic N at the end of 12 weeks incubation was dependent on sludge rate and slightly affected by N addition. Cumulative mineralized N at 0, 40, 80, and 160 t ha^{-1} sludge treatments were 15.4. 83.7, 105.1, and 165.0 mg kg^{-1} soil, respectively. In case of sludge and N addition, these figures were 10.2, 99.6, 108.4, and 180.4 mg kg^{-1} soil. N mineralization rate constant *K* increased from 0.214 in the control to 0.303, and 0.439, then decreased to 0.309 $week^{-1}$ in soil treated with 0, 40, 80, and 160 t ha^{-1} sludge, respectively. Mean *K* values decreased with N addition and when excluding inorganic N found in soil and sludge at the start. Nitrogen mineralization potential N_0 values greatly increased with sludge and N addition. A salt mixture of (1:1 NaCl:$CaCl_2$) at a concentration of 7.5 mg g‘1 soil delayed nitrification in unmended soil, while 15 mg g^{-1} caused complete inhibition. In sludge treated soil, retardation and complete inhibition of nitrification occurred at 7.5 and 60 mg g^{-1} salt mixture, respectively. Complete inhibition of ammonification occurred at salt mixture of 30 mg g^{-1} soil. Drying of either control or amended soil led to a marked drop in NH^{4+} -N and NO^{2-} + NO^{3-} -N content of soil. Both NH^{4+} N and NO^{2-} + NO^{3-} -N increased during wetting cycles. Mineralization was greater after 4 cycles of wetting and drying than after the first cycle finding of Abdel *et al* [1]. Low-temperature pyrolysis of biomass produces a product known as *biochar* The incorporation of this material into the soil has been advocated as a C sequestration method (Clough *at al*[7]. Biochar also has the potential to influence the soil N cycle by altering nitrification rates and by adsorbing NH_4^+ or NH_3. Biochar can be incorporated into the soil during renovation of intensively managed pasture soils. These managed pastures are a significant source of N_2O, a greenhouse gas, produced in ruminant urine patches. We hypothesized that biochar effects on the N cycle could reduce the soil inorganic-N pool available for N_2O-producing mechanisms. A laboratory study was performed to examine the effect of biochar incorporation into soil (20 Mg ha^{-1}) on N_2O-N and NH_3–N fluxes, and inorganic-N transformations, following the application of bovine urine (760 kg N ha^{-1}). Treatments included controls (soil only and soil plus biochar), and two urine treatments (soil plus urine and soil plus biochar plus urine). Fluxes of N_2O from the biochar plus urine treatment were generally higher than from urine alone during the first 30 d, but after 50 d there was no significant difference (P = 0.11) in terms of cumulative N_2O-N emitted as a percentage of the urine N applied during the 53-d period; however, NH_3–N fluxes were enhanced by approximately 3% of the N applied in the biochar plus urine treatment compared with the urine-only treatment after 17 d. Soil inorganic-N pools differed between treatments, with higher NH4 + concentrations in the presence of biochar, indicative of lower rates of nitrification. The inorganic-N pool available for N_2O-producing mechanisms was not reduced, however, by adding biochar. Application of different INM packages markedly influenced residual major soil nutrients (organic C, organic matter and total

N, and available P and K) were also influenced greatly due to different nutrient management practices and moisture levels, in which highest values of concentration and uptake as well as residual major soil nutrients exhibited with the application of vermicompost + chemical fertilizers irrigated at IW : CPE ratio 1.0. Reported by Puste *et al*[26]. And Lagomarsino *et al*[16]. Subehia and Dhanika[34] studied on rice yield and nitrogen dynamics in an on-going field experiment and reported that nitrogen substitution to the tune of 25 to 50% of the recommended dose was made through different organic sources on irrigated rice (*Oryza sativa* L.) and (*Triticum aestivum* L.) rotation on a silty clay loam soil continuously for seventeen years. Sub-optimal levels of NPK (50 and 75% of the recommended) were also applied through mineral fertilizers. Application of both the mineral fertilizers alone or in combination with organics increased all the inorganic and organic fractions of N in soil, except unidentified N. The unidentified N decreased with increasing levels of fertilizers. Inorganic and organic forms of nitrogen contributed about 4.3 and 95.7%, respectively, towards total soil nitrogen. The use of inorganic fertilizers in conjunction with organics increased rice grain and straw yields over only inorganically treated plots. Highest grain and straw yield of rice was recorded when 50% N was substituted through FYM. How can be equated. In Transplanted rice 50% substitution of N through FYM produced 2.9 Mg ha $^{-1}$ rice grain against the 2.5 grain rice in substitution of 50% N throw straw. Zhao *et al*[41].

Grain and Straw Yield: The grains and straw yield (kg ha-^{1}) were recorded treatment wise and Table 4 reveals that inorganic and organic practices significantly increased grain and straw yield over farmer practices during both the years. Significantly higher (4225 and 3744 kg ha-^{1}), (4561 and 4347 kg ha-^{1} grain and straw yield in 2013 – 14 and 2014 - 15 were recorded under application of 75% RDF+2.5 ton FYM ha^{-1}+ PSB+ $ZnSO_4$@ 25 kg ha^{-1}, which was statistically identical to 150% RDF (3427 to 3343 kg ha-^{1}) and (4012 to 3991 kg ha-^{1}) grain and straw yield in 2013-14 and 2014-15, respectively) and superior over other inorganic and organic treatments during both the years. However, treatment (T_4) NPK application on the STCR basis, (T_5) 50% RDF+5 ton FYM +PSB+ Zn So_4 25 kg ha-^{1}, and (T_7) FYM @10 ton/ha+ PSB+ Azotobactor conjoint application of inorganic with organic were at par but were Superior over control during both the years. The lowest value of this parameter 1940 kg ha-^{1} and 2244 kg ha-^{1} in 2013-14 and 1889 kg ha-^{1} and 2245 kg ha-^{1} in 2014-15 were noted under farmer practices plot. The residual soil fertility improved considerably with the combined application of inorganic fertilizer and organics. It was concluded that integration of organics *Rhizobium*, PSB & FYM) with inorganics led to 50% saving of inorganic fertilizer without scarifying the yield of sunnhemp-rice cropping sequence and improved soil fertility status. Tripathi *et al* [36]. Effect of nutrient management in wheat on yield of and nutrient uptake by wheat and soil properties. After three years conjoint use of 10 t FYM ha^{-1} with 100% NPK significantly improved the organic carbon and available N, P and K contents over the chemical fertilizers alone. Integrated nutrient management (100% NPK + 10 t FYM ha^{-1}) maximized yields of wheat crop and improved the soil fertility in the intermediate zone of Jammu and Kashmir. Chesti *et al*[6] and Mauriya *et al*[17]. Similarly, recommended dose of inorganic fertilizer (F_{100}) gave significantly higher yield of wheat grain and straw by Naik *et al*[21], Milkha and Aulakh[18], Singh *et al*[31]. Application of organic manure (FYM) integrated with recommended dose of fertilizers and biofertilizers (PSB + BGA/*Azotobacter*) further increased the yield and yield attributing characters of rice and wheat which was similar to 125% recommended dose of fertilizers. by Lal *et al*[2], Fertilizers constitute an integral part of improved crop production technology. Proper amount of fertilizer application is considered a key to the higher crop production. Yadav *et al*[38].Over-application of nitrogen (N) in North Central China is primary reasons for yield restriction and low nutrient use efficiencies by Ping *et al*[23]. The effect of fertilizers indicated that grain and straw yields of wheat were increased more prominently with the addition of 150 kg N, 60 kg P2O5, 50 kg K2O and 5 t of FYM ha^{-1}. By Bhaduri and Gautam[3], Mubarak and Singh[19]. Integrated nutrient management system for maize-wheat cropping system in an Alfisol. Grain yield of maize, wheat and the system under 50% N through FYM + 50% through chemical fertilizers was significantly higher than that under 100% chemical fertilizers applied to both the crops and was on par with 25% N through FYM and 75% through inorganic source by Prasad *et al*[25]. Effect of nutrient management practices (NM) on growth and yield of wheat (*Triticum aestivum* L.). The experiment consists of eleven treatments viz., T_1-100% recommended dose of fertilizer (RDF) i.e. 120 : 26.4 : 50 N : P : K kg ha-^{1}, T_2- 100% RDF+Vermicompost @ It ha-^{1}, T_3-100% RDF+Vermicompost @ It ha-^{1} + Phosphate Solubilizing bacteria (PSB), T_4-100% RDF+PSB, T_5-75% RDF+ vermicompost @ 1t ha^{-1}, T_6- 75% RDF+vermicompost @ 1t ha-^{1} + PSB, T_7-50% RDF+Vermicompost @ 1t ha^{-1}; T_8-50% RDF+Vermicompost @ 1t ha^{-1}; + PSB, T_9-Vermicompost @ 1t ha^{-1}; + PSB, T_{10}-Vermicompo@st 1t ha^{-1} and T_{11}-absolute control. The results revealed that the application of 100% recommended dose of fertilizers (RDF) i.e. 120:26:4:50 N:P:K kg ha-'+ vermicompost @ 1t ha-^{1} + phosphate solubilizing bacteria (PSB) and 75% RDF + vermicompost @1t ha-^{1}+ PSB produced higher yield attributes and grain yield than the other treatments. The higher yield led to higher NPK uptake by wheat. Further, the available NPK content of soil also increased in above NM treatment over control. The highest benefit: cost ratio (2.73) was obtained from the application of 75% RDF + vermicompost @1t hd1+ PSB. by Devi *et al*[8], Siddiqui *et al*[30]. Revealed that the yield and yield contributing characters of wheat showed positive response with an increase in nitrogen levels up to 160 kg N ha^{-1}. The highest grain yield (3.32 t ha^{-1}) was obtained from 160 kg N ha^{-1}, whereas the lowest (1.51t ha^{-1}) was recorded from 0 kg N ha^{-1}. Application of 200 kg N ha^{-1} decreased grain yield. The variety Shatabdi produced the highest grain yield (3.63 t ha^{-1}) and Protiva produced the lowest grain yield (3.12 t ha^{-1}).

Table 1: Treatment details of experiment

S. No.	Treatments	Symbols used
1	Control/Farmer Practice (100 kg ha^{-1} DAP)	T_1
2	100 % RDF(120 N, 60 P_2O_5 and 40 kg K_2O ha^{-1})	T_2
3	150 % RDF	T_3
4	STCR Based NPK Application	T_4
5	INM 1-50% RDF+5 tone FYM + PSB+ $ZnSo_4$ 25 kg ha^{-1}	T_5
6	INM 2-75% RDF+2.5 tone FYM + PSB+ $ZnSo_4$ 25 kg ha^{-1}	T_6
7	Organics Practices FYM @10 tone ha^{-1} +PSB+Azotobactor	T_7

Table 2: Effect of nutrient management practices on nutrient use efficiency of N, P and K

Treatments	N			P			K		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
T_1	-	-	-	-	-	-	-	-	-
T_2	47.80	35.68	41.74	8.32	8.35	8.33	20.51	23.65	22.08
T_3	54.58	41.51	48.05	8.74	10.03	9.39	28.47	30.54	29.50
T_4	36.18	32.78	34.48	4.74	8.22	6.48	17.86	23.98	20.92
T_5	73.61	52.80	63.21	10.81	12.50	11.65	33.43	37.39	35.41
T_6	53.11	38.57	45.84	11.05	8.18	9.61	30.00	31.23	30.62
T_7	73.76	61.59	67.68	21.49	26.02	23.75	19.96	31.17	25.56
SEm±	7.45	4.94	4.29	2.22	3.09	1.79	1.15	1.82	1.28
CD(0.05)	22.97	15.22	12.53	6.85	9.52	5.22	3.53	5.62	3.73

Table 3: Effect of nutrient management practices on balance sheet of Nitrogen, Phosphorous and Potassium

Treatments	N (kg ha^{-1})			P (kg ha^{-1})			K (kg ha^{-1})		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
T_1	25.23	3.78	14.51	-47.03	-45.93	-46.48	-47.88	-113.60	-80.74
T_2	-40.32	-82.79	-61.56	-46.27	-47.49	-46.88	-36.15	-119.99	-78.07
T_3	-11.27	-75.58	-43.43	-46.08	-43.62	-44.85	-3.40	-209.71	-106.56
T_4	-10.02	-20.95	-15.49	-34.50	-36.63	-35.56	-1.41	-104.84	-53.13
T_5	-1.87	3.40	0.76	-20.15	-21.33	-20.74	-9.83	-121.61	-65.72
T_6	-36.99	-74.69	-55.84	-69.22	-73.52	-71.37	-29.11	-230.52	-129.81
T_7	49.22	33.61	41.41	-39.34	-37.69	-38.52	-56.77	-117.82	-87.30
SEm±	16.60	12.30	10.59	1.65	2.71	1.52	25.35	24.03	20.70
CD(0.05)	51.14	37.89	30.90	5.10	8.34	4.42	NS	74.05	NS

Table 4: Effect of nutrient management practices on different form of nitrogen in during final year 2013-14 and 2014-15

Treatments	Different form of nitrogen											
	2013-14				2014-15				Pooled Mean			
	Total N (%)	NH_4-N (Mg kg^{-1})	NO_3-N (Mg kg^{-1})	Available - N (kg ha^{-1})	Total N (%)	NH_4-N Mg kg-^{1}	NO_3-N (Mg kg^{-1})	Available - N (kg ha^{-1})	Total N (%)	NH_4-N Mg kg^{-1}	NO_3-N (Mg kg^{-1})	Available - N (kg ha^{-1})
T_1	0.047	32.23	1.16	108.71	0.031	10.17	2.93	84.15	0.039	21.20	2.05	96.43
T_2	0.071	30.18	15.84	117.08	0.045	16.47	5.17	131.71	0.058	23.33	10.51	124.39
T_3	0.066	29.15	17.00	146.35	0.042	17.04	6.22	135.37	0.054	23.09	11.61	140.86
T_4	0.047	30.32	8.65	125.44	0.034	14.17	6.93	94.39	0.040	22.24	7.79	109.92
T_5	0.072	31.02	15.55	150.53	0.045	14.03	7.06	98.78	0.059	22.52	11.30	124.66
T_6	0.093	44.18	43.13	175.62	0.062	23.44	7.85	160.98	0.077	33.81	25.49	168.30
T_7	0.074	31.05	7.17	150.53	0.048	17.30	7.63	139.03	0.061	24.17	7.40	144.78
SEm±	0.002	0.27	0.89	13.30	0.001	0.16	0.93	8.22	0.002	0.85	2.88	8.36
CD(0.05)	0.005	0.82	2.73	40.99	0.003	0.51	2.86	25.33	0.005	2.47	8.40	24.40

Table 5: Effect of different treatment on grain and straw yield (kg ha-^{1}) of wheat during the two years of study

Treatments	Grain Yield (kg ha^{-1})			Straw Yield (kg ha^{-1})		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
T_1	1940	1889	1915	2244	2245	2245
T_2	3424	3188	3306	3479	3644	3561
T_3	3427	3343	3385	4012	3991	4002
T_4	2934	2910	2922	2974	2911	2942
T_5	2951	2921	2936	3045	2981	3013
T_6	4225	3744	3984	4561	4347	4454
T_7	2429	2310	2369	2449	2377	2413
SEm±	16.47	26.78	39.37	43.83	53.73	39.98
C.D. (p=0.05)	50.75	82.53	114.91	135.1	165.58	116.68

CONCLUSION

It may be concluded that fertility treatment has greater impact on nutrient use efficiency, balance sheet of nutrient and different form of nitrogen. As such, grain and straw yield of wheat was significantly recorded in the application of 75% RDF+2.5 ton FYM ha^{-1}+ PSB+ $ZnSO_4$@ 25 kg ha^{-1} followed by 150% RDF and to achieve higher yield and increase fertility of the soil.

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