International Journal of Plant & Soil Science

15(6): 1-9, 2017; Article no.IJPSS.32514
ISSN: 2320-7035

Effect of Tropical Legumes on Soil Nutrient Dynamics and its Consequence on Rice Production

Y. M. Ramesha[1*], Manjunatha Bhanuvally[2], Ashok Kumar Gaddi[2], S. A. Biradar[1] and M. R. Umesh[1]

[1]Department of Agronomy, University of Agricultural Sciences, Raichur-584 102, Karnataka, India.
[2]Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, Raichur-584 102, Karnataka, India.

Authors' contributions

This work was carried out in collaboration between all authors. Author YMR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MB and AKG managed the analyses of the study. Author AKG managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2017/32514
Editor(s):
(1) Susana Rodriguez-Couto, Unit of Environmental Engineering, Paseo Manuel Lardizabal, Donostia-San Sebastián, Spain.
Reviewers:
(1) Nirmali Gogoi, Tezpur Central University, Assam, India.
(2) Samson Manono Makone, Kisii University, Kenya.
Complete Peer review History: http://www.sciencedomain.org/review-history/18990

Original Research Article

Received 28th February 2017
Accepted 23rd March 2017
Published 9th May 2017

ABSTRACT

Background and Scope: In Tungabhadra command area of Karnataka, India, soil productivity and yield of crops is declining year after year due to continues flood irrigation for rice and farmers are practicing only mono-cropping (rice-rice) so that possibility of accumulation of salts in the soil leads to salinity and reduction in the soil productivity. To overcome these problems, we hypothesized that growing tropical legumes in paddy fallow during summer and incorporation of these tropical legumes in to soil to improve the soil productivity therefore improving the soil nutrient dynamics and conserve soil organic carbon content that would result in higher grain yield of rice.

Conclusion: Overall, the soil nutrient status was improved and increased the yield of succeeding crop rice when incorporating the tropical legumes in to soil. Our results suggested that, growing leguminous plants during summer in paddy fallow and incorporated after two months, this improved the soil nutrient status and offcourse, increases the yield of succeeding crop of rice.

**Corresponding author: E-mail: rameshaym@gmail.com;*

Keywords: Tropical legumes; incorporation; DSR; uptake of nutrients.

ABBREVIATIONS

DSR : Direct seeded rice
DAS : Days after sowing
DAI : Days after incorporation
DAP : Diamonium Phosphate
MOP : Muriate of potash
RDF : Recommended dose of fertilizer

1. INTRODUCTION

Tropical legumes which are used as bio-fertilizer, plants and their parts (stem, leaves, twigs or roots) that are used into the soil by incorporating them or without any incorporation to improve soil health by adding nutrients contained in them and hence increasing to content of plant nutrients of soil with an goal of obtaining increased crop productivity and crop yields. There are wide range of tropical legumes, some are cultivated and some wildly grown in nature. Some tropical legumes develop nodules in stem, in roots and in some both. Nodule forming green manuring crops contains *Rhizobium* bacteria which has the ability to fixing of atmospheric nitrogen and produces N for the crop itself and to the soil. Other leguminous plants which are grown but rich in nutrient content such as cowpea, field bean, blackgram, cluster bean, horsegram, pillepiesru etc., also can supply plant nutrients after incorporation into the soil.

Rice (*Oryza sativa* L.) is the most important cereal crop in Asia, grown under varying hydrological conditions. It is the principal source of food for more than half of the world population [1], especially in South and Southeast Asia, Latin America and Indonesia. In India, it is a dominating staple food crop of fertile and alluvial soils of north west India, particularly Indo-Gangetic plains [2]. It occupies 36.95 million hectares with a total production of 80.41 million tonnes of rice. Its cultivation is mainly practised through transplanting which is cumbersome and labour intensive. This technique requires puddling and continuous ponding of water for first 15 days for establishment of the seedlings. It leads to nutrient losses through leaching besides causing high evapotranspirational losses during hot summer. Therefore, of late, need has acutely been felt to develop technically viable and economically feasible alternate technique for growing paddy in this area. In this context direct seeded rice (DSR) provides an option. It saves labour and water and make paddy cultivation cost effective. It matures earlier (7-10 days) than the transplanted crop due to the absence of transplanting shock [3] and allows timely planting of succeeding crop. It also ensures the timely sowing in a stipulated time frame. Direct seeded rice accounts for 35 per cent of the total rice cultivated area in India [4]. Nutrient management methods are the major factor that determines the productivity of a crop and soil health.

Direct seeded rice needs higher nutrient requirement as compared to transplanted rice because of the higher plant density and greater production of biomass in the vegetative phase. Thus, direct seeded rice tend to develop nutrient deficiency at the reproductive stage of growth and senesce earlier. Application of external fertilizers along with incorporation of green manures ensures available more nutrients to rice crop and consequently resulted in higher yield [5]. All these factors affect not only the productivity of crop but also the nutrient uptake by the crop during growth and development. Therefore, a field experiment was conducted to study the effect of incorporation of tropical legumes on soil nutrient dynamics and its effect on succeeding crop rice.

2. MATERIALS AND METHODS

A field experiments were conducted during 2014 and 2015 on incorporation of tropical legumes in to soil and its effect on succeeding crop under paddy fallow at Agricultural Research Station, Dhadesugur, University of Agricultural Sciences, Raichur, Karnataka (India) situated at 15.6’ N latitude and 76.8’ E longitude with an altitude of 358 m above mean sea level. The soil of the experimental site was deep black and neutral in pH (8.04), EC (0.47 ds/m), medium in organic carbon content (0.41%), low in soil available nitrogen (192 kg/ha), medium in phosphorus (58.5 kg/ha) and potassium (287.5 kg/ha). **Experiment I:** There are eight tropical legumes tested in this experiment and considered as eight treatments *viz*., T_1: Horsegram (*Macrotyloma uniflorum*), T_2: Cowpea (*Vigna unguiculata*), T_3: Fieldbean (*Vicia faba*), T_4: Clusterbean *(Cyamopsis tetragonoloba),* T_5: Diancha (*Sesbania sp*), T_6: Sunhemp (*Crotalaria juncea*), T_7: Pillepiesru (*Vigna trilobata*) and T_8: Blackgram (*Vigna mungo*) and replicated thrice. These tropical legumes were sown in month of May first week in both the years. Five plants were selected for the purpose of recording observations such as plant height and number leaves per plant in each treatment in each replication. Green biomass of tropical legumes was harvested in the month of July first week in both the years and recorded as net plot yield and converted in to yield per hectare and incorporated in soil with the same quantity in respective plots with tractor drawn rotovator. **Experiment II:** There are nine treatments *viz*., T_1: Incorporation of Horsegram (*Macrotyloma uniflorum*) + RDF (150:75:75 NPK kg/ha), T_2: Incorporation of Cowpea (*Vigna unguiculata*) + RDF, T_3: Incorporation of Fieldbean (*Vicia faba*) + RDF, T_4: Incorporation of Clusterbean *(Cyamopsis tetragonoloba)+ RDF,* T_5: Incorporation of Diancha (*Sesbania sp*) + RDF, T_6: Incorporation of Sunhemp (*Crotalaria Juncea*) + RDF, T_7: Incorporation of Pillepiesru (*Vigna trilobata*) + RDF and T_8: Incorporation of Blackgram (*Vigna mungo*) + RDF and T_9: Control (Only RDF) and replicated thrice. The rice variety used was *'BPT-5204'* of 150 days duration. The crop was sown in the 3rd week of July in both the years. The recommended dose of fertilizer was applied as per the treatments. For observation, five plants were randomly selected in each plot of each replication and were tagged for the purpose of recording observations on growth parameters *viz.,* plant height and number of productive tillers per hill at harvest. Yield parameter *viz.,* number of filled grains per panicle. Similarly, paddy from each net plot in each replication was harvested and dried. The grains after threshing were weighed and recorded as grain yield per net plot. Further, this net plot grain yield was converted to grain yield per hectare and statistically analysed the data [6].

The plant samples were collected for recording dry matter production and estimation of nutrient concentration. The plant samples used for recording dry matter production at harvest were used for analyzing nutrients present in the plant. After recording the dry weight from each treatment the samples were powdered in a micro Willey mill. The samples were analyzed for concentration of different nutrients (N, P and K) present in the plant parts. Nitrogen Phosphorus and potassium content of stover was estimated by modified micro-kjeldhal's method, Vanadomolybodo phosphoric acid yellow colour method and absorbance of the solution was recorded at 430 nm using spectrophotometer and flame photometer method, respectively [7]. Similarly, Available nitrogen was determined by alkaline permanganate method as outlined by [8]. Available phosphorus was determined by Bray's method as outlined by [7]. Available potassium was determined by neutral normal ammonium acetate solution using flame photometer as outlined by [7]. Balance of nitrogen, phosphorus and potassium were worked out by considering the respective total of initial soil available N, P_2O_5 and K_2O. The N, P_2O_5 and K_2O were supplied through fertilizers (Urea, DAP and MOP, respectively) and manures (tropical legumes incorporation). The expected nutrient balance was arrived by subtracting N, P_2O_5 and K_2O uptake by the crop from the total soil N, P_2O_5 and K_2O [9].

3. RESULTS AND DISCUSSION

3.1 Weather Condition during Crop Growth Period

The meteorological data prevailed during the crop growth period and mean of 32 years was recorded at meteorological station located at experimental site are presented in Figs. 1 and 2. The total actual rainfall received during *kharif-2014* was 339.0 mm and 2015 was 655.6 mm. It was almost good as compared to the average normal rainfall received over the last thirty years. The overall pest and disease incidence was least during this season.

3.2 Growth and Green Biomass Yield of Tropical Legumes

The mean data of 2014 and 2015 on growth parameters and green biomass yield of tropical leguminous plants is presented in Table 1. Results revealed that, Taller plants (80.2 cm) having number of leaves per plant (20.0) and higher green biomass yield (5333 kg/ha) were recorded significantly in Diancha was grown under paddy fallow compared to other tropical legumes grown under paddy fallow. Whereas, blackgram was grown under paddy fallow recorded shorter plants (54.2 cm) and having less number of leaves per plant (5.80) led to lower green biomass yield (1533 kg/ha).

3.3 Nutrient Concentration of Tropical Legumes at 60 DAS under Paddy Fallow

Nutrient concentration of tropical leguminous plants is presented in Table 2. Results revealed that, Diancha plants contains significantly higher amount of nitrogen (3.5%) and Phosphorus (0.60%) followed by horse gram (3.52 and

0.14%, respectively) and Pillepiesru (3.12 and 0.15%, respectively). Further, Sunhemp plants contains significantly higher amount of potassium (1.80%) followed by cluster bean (1.62%) and field bean (1.32%).

3.4 Effect of Incorporation of Tropical Legumes on Soil Nutrient Dynamics

The mean data of 2014 and 2015 on nutrient dynamics as influenced by the incorporation of tropical legumes in to soil at 15 DAI is presented in Table 3. Results revealed that, Incorporation of diancha plants in soil significantly increases the organic carbon content (0.51%), available nitrogen (230.1 kg/ha), phosphorus (64.2 kg/ha) and potassium (325.5 kg/ha) and which was onpar with the incorporation of sunhemp (0.46%, 228.4, 63.5 and 322.3 kg/ha, respectively), horsegram (0.48%, 227.3, 62.5 and 320.9 kg/ha, respectively) and pillepiesru (0.42%, 226.5, 62.1 and 319.2 kg/ha, respectively). Further, incorporation of tropical legumes in soil increases the soil organic carbon content and available nutrients over to control plot where there is no incorporation of tropical legumes. Reports also showed that green manuring of leguminous plants *viz*., Diancha, Sunhemp *etc*., significantly increased available nitrogen, phosphorus and potassium levels in the soils [10] and [11].

3.5 Effect of Incorporation of Tropical Legumes and Application of RDF on Growth and Yield of Succeeding Crop

Growth and yield of direct seeded rice as influenced by the incorporation of tropical leguminous plants is presented in Table 4. Results revealed that, Incorporation of diancha plants in soil along with the application of recommended dose of fertilizer was significantly increases the plant height (82.2 cm), productive tillers per plant (236), filled grains per panicle (273) and grain yield (6069 kg/ha) and which was onpar with the incorporation of sunhemp in soil along with the application of recommended dose of fertilizer (81.0 cm, 232, 271, and 5911 kg/ha, respectively), incorporation of horsegram in soil along with the application of recommended dose of fertilizer (80.1 cm, 230, 270 and 5804 kg/ha, respectively) and incorporation of pillepiesru in soil along with the application of recommended dose of fertilizer (79.1 cm, 228, 269 and 5786 kg/ha, respectively). Further, incorporation of tropical legumes in soil increases the growth and yield of direct seeded rice over to control plot where there is no incorporation of tropical legumes. Dhaincha, Sunhemp and Pillepiesru are popular green-manuring crop for rice and it is reported that rice grain yield was drastically in green manured treatments [10].

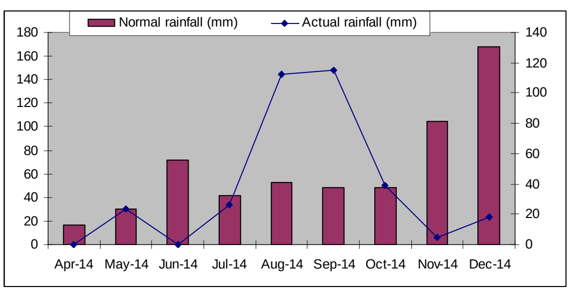

Fig. 1. Monthly rainfall (mm) during *Kharif* 2014

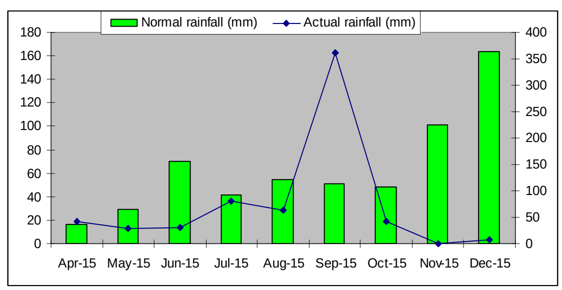

Fig. 2. Monthly rainfall (mm) during *Kharif* 2015

Table 1. Growth and biomass yield of tropical legumes at 60 DAS (Mean data of 2014 and 2015)

Treatments	Plant height (cm)	Number of leaves per plant	Green biomass yield (kg/ha)
T_1:Horsegram	60.5 d	16.3 b	4333 b
T_2:Cowpea	75.2 b	15.0 c	4000 c
T_3:Fieldbean	76.2 b	15.6 c	4167 c
T_4:Clusterbean	65.2 c	11.3 d	3000 d
T_5:Diancha	80.2 a	20.0 a	5333 a
T_6:Sunhemp	81.5 a	16.6 b	4433 b
T_7:Pillepiesru	60.2 d	15.0 c	4200 b
T_8:Blackgram	54.2 e	5.80 e	1533 e

Table 2. Nutrient concentration of tropical legumes at 60 DAS (Mean data of 2014 and 2015)

Treatments	Nitrogen (%)	Phosphorus (%)	Potassium (%)
T_1:Horsegram	3.52 a	0.14 c	1.12 c
T_2:Cowpea	3.15 a	0.25 c	1.15 c
T_3:Fieldbean	3.12 a	0.21 c	1.32 b
T_4:Clusterbean	2.12 b	0.41 b	1.62 a
T_5:Diancha	3.50 a	0.60 a	1.20 b
T_6:Sunhemp	2.30 b	0.50 a	1.80 a
T_7:Pillepiesru	3.12 a	0.15 c	1.25 b
T_8:Blackgram	2.10 b	0.15 c	1.21 c

Table 3. Soil pH, organic carbon and available N, P, K at 15 DAI of tropical legumes (Mean data of 2014 and 2015)

Treatments	pH	O.C (%)	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)
T_1:Horsegram	7.12 a	0.48 a	227.3 a	62.5 a	320.9 a
T_2:Cowpea	7.41 a	0.42 a	225.5 b	61.5 a	315.8 b
T_3:Fieldbean	7.52 a	0.45 a	224.9 b	61.2 a	314.6 b
T_4:Clusterbean	7.62 b	0.48 b	215.8 c	60.2 b	312.4 c
T_5:Diancha	7.23 a	0.51 a	230.1 a	64.2 a	325.5 a
T_6:Sunhemp	7.12 a	0.46 a	228.4 a	63.5 a	322.3 a
T_7:Pillepiesru	7.58 a	0.42 a	226.5 a	62.1 a	319.2 a
T_8:Blackgram	7.54 b	0.42 b	212.3 c	60.1 b	310.1 c
T_9:Control	8.04 c	0.41 c	205.2 d	58.5 d	287.5 d

3.6 Effect of Incorporation of Tropical Leguminous Plants and Application of RDF on Uptake of DSR

The mean data pertaining to nitrogen, phosphorus and potassium uptake by direct seeded rice at harvest during 2014 and 2015 is presented in Tables 5-7. Nitrogen, phosphorus and potassium uptake by direct seeded rice varied due to varied levels of incorporation of tropical leguminous plants during both the years. Significantly higher uptake of nitrogen, phosphorus and potassium were recorded with the incorporation of diancha plants in soil along with the application of recommended dose of fertilizer (172.3, kg N ha^{-1}, 32.1 kg P_2O_5 ha^{-1} and 274.2 kg K_2O ha^{-1}, respectively compared to other incorporation of leguminous plants in soil along with the application of recommended dose of fertilizer. The higher N, P and K uptake by the crop during both the years was due to increase in grain and stover yield. It may be due to higher availability of nutrients by synergistic effect of incorporation of organic sources with inorganic fertilizers. [12] observed higher N, P and K uptake due to addition of leguminous plants in conjunction with *Rhizobium*. The *Rhizobium* produce photo-hormones which can stimulate root growth and induce changes in root morphology and increases the surface area as a result of root proliferation, which inturn could increase assimilation of nutrients. Significantly lower uptake of nitrogen, phosphorus and potassium were recorded in the treatment with the only application of recommended dose of fertilizer (147.2 kg N ha^{-1}, 20.5 kg P_2O_5 ha^{-1} and 255.1 kg K_2O ha^{-1}, respectively) compared to other treatments. The lower N, P and K uptake during both the years was due to lower grain and stover yield may be due to lower availability of nutrients [13] and [14].

3.7 Effect of Incorporation of Tropical Leguminous Plants and Application of RDF on Availability of Nutrients in Soil after Harvest of DSR

Higher available nitrogen, phosphorus and potassium (230.4 kg N ha^{-1}, 68.5 kg P_2O_5 ha^{-1} and 318.2 kg K_2O ha^{-1}, respectively) in soil after harvest of the crop was recorded with the only application of recommended dose of fertilizer. This might be owing to lower uptake of nitrogen, phosphorus and potassium. Whereas, lower available nitrogen, phosphorus and potassium (207.5 kg N ha^{-1}, 58.5 kg P_2O_5 ha^{-1} and 300.2 kg K_2O ha^{-1}, respectively) were recorded in soil after harvest of the crop in the treatment with the incorporation of diancha plants and application of recommended dose of fertilizer (Tables 5-7).

Table 4. Effect of incorporation of tropical legumes and application of RDF on succeeding crop of DSR (Mean data of 2014 and 2015)

Treatments	Plant height (cm)	No. of productive tillers/m^2	No. of filled grains/panicle	Grain yield (kg/ha)	Straw yield (kg/ha)	% of increase in grain yield
T_1:Incorporation of Horsegram + RDF	80.1 a	230 a	270 a	5804 a	7027 a	14.6 b
T_2:Incorporation of Cowpea + RDF	78.1 b	224 b	264 b	5625 b	6854 b	11.1 c
T_3:Incorporation of Fieldbean +RDF	76.7 b	222 b	263 b	5521 b	6788 b	9.02 c
T_4:Incorporation of Clusterbean +RDF	73.0 a	196 c	260 c	5398 c	6542 c	6.60 d
T_5:Incorporation of Diancha +RDF	82.2 a	236 a	273 a	6069 a	7270 a	19.8 a
T_6:Incorporation of Sunhemp +RDF	81.0 a	232 a	271 a	5911 a	7185 a	16.7 b
T_7: Incorporation of Pillepiesru +RDF	79.1 a	228 a	269 a	5786 a	6911 a	14.3 b
T_8: Incorporation of Blackgram +RDF	72.0 c	184 c	262 c	5277 c	6483 c	4.21 d
T_9:Control (RDF)	70.1 d	180 d	260 d	5064 d	6206 d	-

Table 5. Nitrogen balance in soil after harvest of DSR as influenced by the incorporation of tropical legumes and application of RDF (Mean data of 2014 and 2015)

	Initial soil available N (kg ha^{-1})	Addition of N through fertilizer and tropical legumes (kg ha^{-1})	Total N (kg ha^{-1})	Crop uptake of N (kg ha^{-1})	Expected N balance (kg ha^{-1})	Actual N balance (kg ha^{-1})	Net loss (-) (kg ha^{-1})
Treatment	(1)	(2)	3=(1+2)	(4)	5=(3-4)	(6)	7=(6-5)
T_1:Incorporation of Horsegram + RDF	227.3 a	302.5	529.8	165.2	364.6	211.8	-152.8
T_2:Incorporation of Cowpea + RDF	225.5 b	290.8	516.3	163.2	353.1	215.3	-137.8
T_3:Incorporation of Fieldbean +RDF	224.9 b	296.7	521.6	162.5	359.1	217.4	-141.7
T_4:Incorporation of Clusterbean +RDF	215.8 c	255.6	471.4	160.0	311.4	221.5	-98.9
T_5:Incorporation of Diancha +RDF	230.1 a	337.7	567.8	172.3	395.5	207.5	-188
T_6:Incorporation of Sunhemp +RDF	228.4 a	306.0	534.4	168.5	365.9	210.3	-155.6
T_7: Incorporation of Pillepiesru +RDF	226.5 a	297.8	524.3	164.2	360.1	214.5	-145.6
T_8: Incorporation of Blackgram +RDF	212.3 c	204.0	416.3	159.2	257.1	225.4	-46.7
T_9:Control (RDF)	205.2 d	150	355.2	147.2	208.0	230.4	-5.6

Table 6. Phosphorus balance in soil after harvest of DSR as influenced by incorporation of tropical legumes and application of RDF (Mean data of 2014 and 2015)

Treatment	Initial soil available P_2O_5 (kg ha^{-1}) (1)	Addition of P_2O_5 through fertilizer and manures (kg ha^{-1}) (2)	Total P_2O_5 (kg ha^{-1}) 3=(1+2)	Crop uptake of P_2O_5 (kg ha^{-1}) (4)	Expected P_2O_5 balance (kg ha^{-1}) 5=(3-4)	Actual P_2O_5 balance (kg ha^{-1}) (6)	Net loss (-)/ Net gain (+) (kg ha^{-1}) 7=(6-5)
T_1:Incorporation of Horsegram + RDF	62.5 a	81.1	143.6	30.2	113.4	60.2	-53.2
T_2:Incorporation of Cowpea + RDF	61.5 a	80.6	142.1	27.1	115.0	62.5	-52.5
T_3:Incorporation of Fieldbean +RDF	61.2 a	80.8	142.0	25.3	116.7	63.5	-53.2
T_4:Incorporation of Clusterbean +RDF	60.2 b	79.2	139.4	24.2	115.2	64.5	-50.7
T_5:Incorporation of Diancha +RDF	64.2 a	82.5	146.7	32.1	114.6	58.5	-56.1
T_6:Incorporation of Sunhemp +RDF	63.5 a	81.2	144.7	31.5	113.2	59.8	-53.4
T_7: Incorporation of Pillepiesru +RDF	62.1 a	80.9	143.0	28.2	114.8	61.5	-53.3
T_8: Incorporation of Blackgram +RDF	60.1 b	77.1	137.2	22.1	115.1	65.8	-49.3
T_9:Control (RDF)	58.5 d	75.0	133.5	20.5	113.0	68.5	-44.5

Table 7. Potassium balance in soil after harvest of DSR as influenced by incorporation of tropical legumes and application of RDF (Mean data of 2014 and 2015)

Treatment	Initial soil available K_2O (kg ha^{-1}) (1)	Addition of K_2O through fertilizer and manures (kg ha^{-1}) (2)	Total K_2O (kg ha^{-1}) 3=(1+2)	Crop uptake of K_2O (kg ha^{-1}) (4)	Expected K_2O balance (kg ha^{-1}) 5=(3-4)	Actual K_2O balance (kg ha^{-1}) (6)	Net gain (+) (kg ha^{-1}) 7=(6-5)
T_1:Incorporation of Horsegram + RDF	320.9 a	123.5	444.4	270.1	174.3	305.4	+131.1
T_2:Incorporation of Cowpea + RDF	315.8 b	119.8	435.6	266.3	169.3	308.5	+139.2
T_3:Incorporation of Fieldbean +RDF	314.6 b	121.7	436.3	265.1	171.2	310.2	+139.0
T_4:Incorporation of Clusterbean +RDF	312.4 c	108.6	421.0	262.3	158.7	312.1	+153.4
T_5:Incorporation of Diancha +RDF	325.5 a	134.7	460.2	274.2	186.0	300.2	+114.2
T_6:Incorporation of Sunhemp +RDF	322.3 a	124.6	446.9	272.6	174.3	302.1	+127.8
T_7: Incorporation of Pillepiesru +RDF	319.2 a	122.0	441.2	268.5	172.7	307.2	+134.5
T_8: Incorporation of Blackgram +RDF	310.1 c	92.2	402.3	260.1	142.2	315.1	+172.9
T_9:Control (RDF)	287.5 d	123.5	362.5	255.1	107.4	318.2	+210.8

This might be due to higher uptake of nitrogen, phosphorus and potassium as influenced by interactive behaviour of organic and inorganic sources of application, which increased the mobilization of nitrogen, phosphorus and potassium in the soil along with external supply of nitrogen, phosphorus and potassium through inorganic sources. Further, increased microbial activity in soil due to conjunctive use of organic sources along with inorganic fertilizer also would have contributed nitrogen, phosphorus and potassium to the available pool which ultimately reflected in the grain and straw yields. These results are in accordance with the studies of [15].

3.8 Effect of Incorporation of Tropical Leguminous Plants and Application of RDF on Balance of Nitrogen, Phosphorus and Potassium in Soil after Harvest of DSR

There was a negative balance of nitrogen observed in all the treatments during both the years. Incorporation of sunhemp plants along with the application of recommended dose of fertilizer recorded higher negative balance of nitrogen (155.6 kg ha^{-1}) The negative balance of nitrogen after harvest of crop might be ascribed to the fact that loss of nitrogen. Similar results also reported by [16]. Similarly, negative balance of phosphorus observed in all the treatments. Incorporation of diancha plants along with the application of recommended dose of fertilizer recorded higher negative balance of phosphorus (56.1 kg P_2O_5 ha^{-1}) This might be due to the fixation of available phosphorus in soils ultimately resulted in net loss of available phosphorus. These results are onpar with the findings of [16]. However, positive balance of potassium was observed in all the treatments. Application of only recommended dose of fertilizer recorded higher positive balance of potassium (210.8 kg K_2O ha^{-1}). The higher positive balance in potassium was probably due to high potassium available in soil. This might be due to the fact that the fixed potassium might have been made available by the rice and enriched the soil, resulting in a positive balance of potassium observed in this treatment, which is unique in nature (Tables 5 to 7).

4. CONCLUSION

From this study, we would like to conclude that, Incorporation of tropical leguminous plants *viz*., Diancha, Sunhemp, Pille piesru etc., in to soil under paddy fallow increases the soil organic carbon content and available nitrogen, phosphorus and potassium. Further, growing of rice by direct sown as succeeding crop under this soil increases the grain yield of rice.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Nguyen VN. Rice production, consumption and nutrition. FAO STAT; 2002.
2. Walia US, Walia MK. Scope of direct seeded rice in India. Proc. Biennial Conference, ISWSon New and Emerging Issues in Weed Science. HAU, Hissar, India. 2007;20.
3. Dhyani VC, Singh VP and Singh G. Response of rice to crop establishment and weed management. Indian J. Weed Sci. 2005;37:260-262.
4. Nageshwari R, Subhramaniayan B. Influence of delayed basal dressing and split application of nitrogen in wet-seeded rice (*Oryza sativa* L.). Indian J. Agron. 200449:40-42.
5. Kumar J, Singh D, Puniya R and Pandey PC. Effect of weed management practices on nutrient uptake by direct seeded rice. Oryza. 2010;47:291-94.
6. Gomez KA, Gomez AA. Statistical procedures for agricultural research (2 ed.). John wiley and sons, New York. 1984;680.
7. Jackson ML. Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi. 1967;183-192.
8. Subbiah BV, Asija CL. A rapid procedure for estimation of available nitrogen in soils. Curr. Sci. 1959;25:259-260.
9. Mongia AD, Gangwar B. Nutrient balance under multiple cropping sequence in an acid soil (Typic Tropofluvents). Indian J. Agron. 1991;36(1):17-22.
10. Gurung GB, Sherchan DP. Green manuring effect of Dhaincha (*Sesbania aculeate* Pers) on rice in the farmer's field. PAC Working Paper No. 192. PAC, Dhankuta. 1997;8.
11. Mathukia RK, Ponkia HP, Polara AM. In situ moisture conservation and zinc fertilization for rainfed pigeonpea (*Cajanus* cajan L.). The Bioscan. 2016; 11(1):247-250.

12. Krishnamoorthy T. Studies on integrated nutrient management in *kharif* sorghum (*Sorghum bicolor* (L.) Moench) in transition tract. M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad; 1995.
13. Negalur RB. Response of *kharif* pop sorghum genotypes to FYM and mineral fertilizer in black soil under rainfed conditions. M.Sc. (Agri) Thesis, University of Agricultural Sciences, Dharwad; 2000.
14. Nagar RK, Goud VV, Rajesh Kumar, Ravindra Kumar. Effect of incorporation of FYM, pigeonpea stalk, phosphocompost on growth, yield and nutrient uptake in pigeonpea based intercropping system. The Bioscan. 2015;10(3):339-343.
15. Gajanana GN, Shankar MA, Somashekar K, Krishnappa AM. Importance of plant nutrient management in dryland agriculture Bulletin. AICRP on Dryland Agriculture, UAS, Bangalore. 2000;1-38.
16. Yin-Po Wang, Cben Ching Chao. The effect of organic farming practices on the chemical, physical and biological properties of soil in Taiwan. FFTC book series No. 1995;46:33-39.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/18990