Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(2): 2440-2444
Received: 18-11-2019
Accepted: 22-12-2019

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Long term effects of rice establishment methods on chemical properties and rice productivity in vertisols of Chhattisgarh plain

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Abstract
The farmer field study was carried out during 2016-17 at village Saida, Takhatpur Tehsil in Bilaspur district of Chhattisgarh to evaluate the “Long term effects of rice establishment methods on chemical properties and rice productivity in vertisols of Chhattisgarh plain”. The trial was laid out in Randomized block design with twelve replication and three treatments. Rice based cropping system in Vertisols. The soil of experiment fields was clay in texture having slightly acidic to slightly alkaline pH, low in nitrogen, medium phosphorus and potassium medium to high. The available iron, manganese, zinc and copper content of the experimental field were sufficient. The study on the long term effect of rice establishment methods on soil chemical properties and crop productivity were evaluated after harvest of rice crop. In this study, three rice establishment methods i.e. transplanting, broadcast-biasi and direct seeded line sowing were laid in main treatment. A study was undertaken to describe the soil resources of the investigation field. The residual effect of rice establishment methods on soil chemical properties like the available nitrogen, phosphorus, potassium and sulphur content were significantly higher in surface layer (0-20 cm) with transplanting method over other treatments however sub surface layer (20-40 cm) was non-significantly increases with transplanting method but also obtained nutrient content decreases in than surface layer. Micro nutrient content in surface layer (0-20 cm) higher than sub surface layer and non-significantly increases with transplanting method.

Keywords: Long term effect of rice establishment, transplanted rice, direct seeded rice, brushing method of rice, tillage, rice

Introduction
Rice is one of the chief grains of India and every day millions of Indians find ease in it. With high carbohydrate content, it is known to provide instantaneous energy, and is a staple that is consumed by the preponderance of India’s population. Our country has biggest area under rice cultivation, as it is single of the foremost food crops and provides food security and source of revenue for the peoples of country and occupies an area out of the 44.1 m ha area an annual production of 105.48 million tones and productivity of 2.39 tonnes/ha of rice (Annual Report 2016-17). Under puddle condition rice cultivation has occupies 24 m ha, about 56% of the area (Anonymous, 2005) [2]. It’s also the world most important cereal crop is grown over an area of 153 m ha a global level and constitutes the staple diet for over 40% of the world population including around 85% of the Asian population. Presently in Chhattisgarh, about 75 per cent area is under broadcasting, 15-17 percent under transplanting and 8-10 per cent area is covered by direct drilling method of rice seeding.
Transplanting has been the most important and common method of crop establishment under favourable rainfed and irrigated lowland in Tropical Asia. In India, 44 per cent of rice area (19.6 million ha) is under transplanting in irrigated lowland. This practice provides several benefits to rice, such as weed control, ease of transplanting, decrease in deep percolation losses of water and nutrients and improved to nutrient availability (Sharma *et al*., 2003). Although puddling is known to be beneficial for growing rice it can adversely affect the growth and yield of subsequent crop.
Under broadcast Biasi method, rice seeds are broadcast in a ploughed field immediately after the onset of monsoon. After about 30 to 45 days when sufficient water is impounded in the field, the fields are ploughed in the standing crop. This is called Biasi or bushening. The uprooted seedlings are transplanted (in situ transplanting) after Biasi, which is called Chalai in local language. In this method of rice cultivation which is generally practiced for the control of weeds in direct seeded shallow lowland rice in various forms in the different parts of Indian farmers, particularly in Chhattisgarh, Orrisa, Madhya Pradesh and Bihar, and to a smaller area in West Bengal, Assam and Utter Pradesh for optimization of stand. The intercultural practices

in water stagnant paddy crop are followed in many countries and named with different terms. Like 'Gogarancah' in Indonesia, 'Kakularf' in Shri Lanka and 'Sabog Tanim' in Phillipines. In our country and Bangladesh, it's an age old practice and known as Aus, Beausani or Biasi (Fujisaka., *et al*, 1993) [6].

In India direct seeded rice has grown in the area of 7.2 M ha. In Chhattisgarh, rice occupies average of 3.77 million ha with the productivity of the state ranging between 1.2 to 1.6 t/ha depending upon the rainfall and the production is 8.58 MT. Direct seeding of rice eliminates the need of nursery raising and subsequent labour intensive transplanting thus reducing cost of cultivation and is now fast replacing traditionally transplanted rice (Balasubramanian and Hill, 2000) [4]. The present study was focus on evaluating the long term effects of rice establishment methods on chemical properties and rice productivity in vertisols of Chhattisgarh plain.

Materials and Methods

A farmer's field experiment was conducted at village-Saida, Takhatpur, Bilaspur District during 2016-17 on a vertisols under categories marginal, medium and resourceful farmer, on the basis of survey out of 50 farmers total 36 farmers selected for research purpose and samples were collected from selected farmer's field. The three treatment of rice establishment method studied viz.

(a) Transplanting
(b) Broadcast-Biasi
(c) Direct seeding (Line sowing) with twelve replications in randomized block design.

Bilaspur district was considered as strata and single village was selected by using Simple Random Sampling without Replacement (SRSWOR). From selected village 36 farmers viz. large (>3ha), medium (1-3 ha) and small (<1ha) were selected for sampling and other basic information about the farmers were collected. From each selected farmer field standard procedure of sampling was followed and sampled fields were positioned as latitude longitude by using GPS. The soil samples were collected from 0-20 and 20-40 cm soil depth within each farmer field for chemical properties of soil. Composite soil sample of each treatment for three replications were taken for the purpose the sample were oven dried at 80ºC for 72 hours than, these were processed for final grinding passed through out a 2 mm sieve and were analysed for the estimation of macro and micro nutrient as per the suitable method. The soil of experiment fields was clay in texture having slightly acidic to slightly alkaline pH, low in nitrogen, medium phosphorus and potassium medium to high. The available iron, manganese, zinc and copper content of the experimental field were sufficient. Data obtained from all observation were statistically analysed by applying Randomized block design (RBD).

Results and Discussion

Soil pH and Electrical Conductivity (dSm^{-1})

The data of soil pH and EC (dSm^{-1}) determined for long term effect of rice establishment methods are presented in table 1. The different rice establishment methods viz transplanting, broadcast-biasi and direct seeded (Line sowing) did not affected the soil pH at 0 to 20 cm. At sub surface (20-40 cm) soil, comparatively higher pH than surface soil was obtained. However, pH values increased with increasing depth (0-20 and 20-40 cm). The soil pH value was slightly higher under transplanting method. The pH value was recorded higher in the transplanted. The trends of variation in EC of soil between the treatments are almost negligible and non-significant. The basic property of soil, electrical conductivity (dSm^{-1}) values increased with increasing depth (0-20 and 20-40 cm). The electrical conductivity value was recorded slightly higher (0.23 dSm^{-1}) in the transplanting method on surface soil; however, it was 0.24 dSm^{-1} in subsurface soil rice on surface soil (7.21) which further increased in subsurface (7.25). Soil pH and EC (dSm^{-1}) slightly increases with depth. The rice establishment methods had no significant response on pH and EC (dSm^{-1}). The soil pH and EC (dSm^{-1}) values showed considerable variation with depth under different treatments. The different rice establishment methods viz transplanting, broadcast-biasi and direct seeded (Line sowing) did not significantly affect the soil pH and electrical conductivity. These results are in line with Mishra *et al.* (2010) [9]. Pulakeshi *et al.*, 2014 also reported that the pH and EC (dsm^{-1}) increased with depth.

Organic Carbon (%)

Data pertaining to soil organic carbon are presented in table 1. It is revealed that the long term different rice establishment methods did not affect the status of organic carbon at both the soil depths. However; the values were slightly higher in transplanting method treatments. Organic carbon was recorded in surface layer was 0.52, 0.51, and 0.50 per cent in transplanting, broadcast-biasi and direct seeded rice, respectively. In next layer (20-40 cm) organic carbon was recorded 0.44, 0.43 and 0.43 per cent in transplanting, broadcast-biasi and direct seeded rice respectively. The soil organic carbon in the 0-20 and 20-40 cm soil depth in transplanting method had higher soil organic carbon (SOC) than the non-transplanting methods. Puddling increases soil organic carbon availability and similar finding was reported by Banerjee *et al.* (2006) [5]. Halvorson *et al.* (1999) [8] reported that, increase in SOC with N application reflected the response of crop biomass to added N. More biomass production also led to greater amount of root exudation. Sapkota *et al.*, (2017) [15] also reported that the conventionally grown rice-wheat leads to depletion of SOC at the rate 0.13 t ha^{-1} yr^{-1} from 0 to 0.6 m depth of eastern OGP.

Table 1: Long term effects of rice establishment methods on pH, Electrical Conductivity and Per-cent of Organic Carbon of soil at harvest with different depth.

Treatments	pH		EC (dsm^{-1})		OC (%)	
	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm
Transplanting	7.21	7.25	0.23	0.24	0.52	0.44
Broadcasting-Biasi	7.10	7.19	0.22	0.23	0.51	0.43
Direct seeded (LS)	7.07	7.17	0.21	0.23	0.50	0.43
CD at 5%	NS	NS	NS	NS	NS	NS

Available Nitrogen

The data presented in table 2. Revealed that soil available nitrogen (kg ha^{-1}) was significantly influenced by different long term rice establishment methods. The change in nitrogen content of surface (0-20 cm) and sub-surface (20-40 cm) soil in relation to rice establishment methods and surface soil shows significant variations in available nitrogen content due to rice establishment methods. Transplanting method was recorded significantly higher soil available nitrogen (230.3 kg ha^{-1}) than broadcast-biasi (216.7 kg ha^{-1}) and direct seeded rice (211.8 kg ha^{-1}). All the three rice establishment methods did not significantly influenced the status of available nitrogen (kg ha^{-1}) in sub surface soil (20-40 cm). However, the values were slightly higher in transplanting method rice. Available nitrogen was recorded 170.2, 166.0 and 165.3 kg ha^{-1} in transplanting method broadcast-biasi and direct seeded rice respectively. However, soil available nitrogen was higher in Transplanting method of rice, in both the depth. The higher available nitrogen in Transplanting method of rice field was due to the restricted water movement to lower depth of profile which helped in minimizing the leaching losses and an indirect increase in the availability of nutrients by puddling is due to a reduction in cation leaching, similar results were reported by Saharawat *et al.* (2005) [14].

Table 2: Long term effects of rice establishment methods on available nutrients of soil at harvest.

Treatments	N (Kg ha^{-1})		P (Kg $ha.^{-1}$)		K (Kg $ha.^{-1}$)		S (Kg $ha.^{-1}$)	
	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm
Transplanting	230.3	170.2	16.36	12.32	459.4	341.0	29.67	19.44
Broadcasting-Biasi	216.7	166.0	14.23	11.12	428.2	332.2	24.19	18.68
Direct seeded (LS)	211.8	165.3	13.80	10.72	419.9	327.5	24.13	18.26
CD at 5%	6.71	NS	1.59	NS	27.87	NS	3.52	NS

Available Phosphorus (kg ha^{-1})

The data presented in table 2. Revealed that phosphorus content of surface (0-20 cm) and sub-surface (20-40 cm) soil in relation to rice establishment methods and surface soil showed significant increased due to rice establishment methods. Transplanting method was recorded significantly higher available phosphorus (16.36 kg ha^{-1}) than broadcast-biasi (14.23 kg ha^{-1}) and direct seeded rice (13.8 kg ha^{-1}). All the three rice establishment methods did not differ significantly in the status of available phosphorus (kg ha^{-1}) in subsurface layer. However, the values were slightly higher in Transplanting method of rice treatment. Available phosphorus (kg ha^{-1}) was recorded 12.32, 11.12 and 10.72 kg ha^{-1} in Transplanting method, broadcast-biasi and direct seeded rice, respectively. The soil available phosphorus (kg ha^{-1}) after rice harvest in the 0-20 cm and 20-40 cm soil depths were higher under Transplanting method, broadcast-biasi than direct seeded rice. However, soil available phosphorus (kg ha^{-1}) in the 20-40 cm soil layer observed negligible change due to rice establishment methods. Similar results were obtained by Rath (1999) [12] where to observe that non-puddling tended to decrease available phosphorus; whereas puddling tended to improve soil available phosphorus. An indirect increase in the availability of nutrients by puddling is due to a reduction in cation leaching, similar results were reported by Sahrawat, *et al.* (2005) [14], Shweta *et al.* (2008) [18] and Mishra *et al.* (2010) [9].

Available Potassium (kg ha^{-1})

Data presented in Table 2 shows the change in available potassium (kg ha^{-1}) of surface (0-20 cm) and sub-surface (20-40 cm) soil in relation to rice establishment methods. Surface soil shows significant variations in available potassium content due to rice establishment methods. Transplanting method recorded significantly higher available potassium (459.4 kg ha^{-1}) than biasi (428.2 kg ha^{-1}) and direct seeded rice (419.9 kg ha^{-1}). All the three rice establishment methods did not differ significantly in the status available potassium (kg ha^{-1}) in the sub soil at harvest of rice but the values were slightly higher in puddled transplanted rice treatments. Available potassium (kg ha^{-1}) content was observed to be 341.0, 332.2 and 327.5 kg ha^{-1} in Transplanting method, broadcast-biasi and direct seeded rice, respectively. The soil available potassium (kg ha^{-1}) after rice harvest in the 0-20 cm and 20-40 cm soil depth were higher under puddled transplanted rice than broadcast-biasi and direct seeded rice. However, in the next layer (20-40 cm) K recorded lower value than the top soil. Variations among different rice establishment methods were not great. Similar results were reported by Mondal, (2016) [10]. Rath (1999) [12] reported that, the available potassium status decreased with increase in the depth of soil. The value of P and K was slightly higher under puddled treatments. This may be due to low leaching losses of N, solubility of P and more K into soil due to soil dispersion. Similar findings were obtained by Sharma and De Datta (1985) [16].

Available Sulphur (kg ha^{-1})

The data show in Table 2. the change in sulphur content of surface (0-20 cm) and sub-surface (20-40 cm) soil in relation to rice establishment methods and surface soil showed significant variations due to rice establishment methods. Transplanting method treatment recorded significantly higher available sulphur (29.67 kg ha^{-1}) than broadcast-biasi (24.19 kg ha^{-1}) and direct seeded (22.13 kg ha^{-1}) rice. All the three rice establishment methods did not differ significantly in the status of available sulphur (kg ha^{-1}) in subsurface layer. However, the values were slightly higher in transplanting rice treatment. Available sulphur (kg ha^{-1}) was recorded to be 19.44, 18.68 and 18.26 kg ha^{-1} in transplanting, broadcast-biasi and direct seed in rice, respectively. The soil available sulphur (kg ha^{-1}) after rice harvest in the 0-20 cm and 20-40 cm soil depths were higher under transplanted rice than broadcast-biasi and direct seeded rice, however, soil available sulphur (kg ha^{-1}) in the 20-40 cm soil layer observed negligible change due to rice establishment methods. An indirect increase in the availability of nutrients by puddling is due to a reduction in cation leaching, similar results were reported by Sahrawat, *et al.* (2005) [14] and Mishra *et al.* (2010) [9].

Table 3: Long term effects of rice establishment methods on available nutrients of soil at harvest.

Treatments	Available Fe (mg Kg-1)		Available Mn (mg Kg-1)		Available Zn (mg Kg-1)		Available Cu (mg Kg-1)	
	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm
Transplanting	36.41	28.22	24.44	21.05	1.20	1.05	3.11	2.61
Broadcasting-Biasi	36.17	28.13	24.17	20.97	1.04	1.04	3.06	2.59
Direct seeded (LS)	36.02	27.97	23.81	21.36	1.02	0.98	2.81	2.53
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS

Available Micronutrients Status of Soil after Harvest of Crop

The status of available micronutrient i.e. Fe, Mn, Zn, and Cu are presented in table 3. The change in micronutrient of surface (0-20 cm) and sub-surface (20-40 cm) soil in relation to rice establishment methods revealed that the micronutrient status of the soil did not affect significantly by different rice establishment method. Highest available Fe, Mn, Zn, and Cu content were recorded 36.41, 24.44, 1.2 and 3.11 mg kg^{-1} with transplanting method. The lowest available micro nutrients Fe, Mn, Zn, and Cu content were recorded 36.02, 23.81, 1.02, and 2.81 mg kg^{-1} with direct seeded rice treatment under surface soil. All the three rice establishment methods did not affect the status of available micronutrients in the soil at 20-40 cm depth. However, again the highest values were recorded in transplanting method of rice treatments. The available micronutrients content was higher in transplanting rice than in broadcast-biasi and direct seeded rice respectively. However, variations were non-significant. The available micronutrient after rice harvest at 0-20 and 20-40 cm depth were higher under transplanted rice. Negligible change was recorded in micronutrient content in soil as influenced by rice cultivation methods. The availability of micronutrients increase by puddling may be due to a reduction in cation leaching. Similar finding was also reported by Sahrawat, *et al.* (2005) [14] and Mishra *et al.* (2010) [9] they reported that the available micronutrient status decreased with increase in the depth of soil.

Table 4: Long term effects of rice establishment methods on grain and straw yield.

Treatments	Yield (Kg ha^{-1})	
	Grain	Straw
Transplanting	4408	4975
Broadcasting-Biasi	3825	4370
Direct seeded (LS)	3417	3904
CD at 5%	251	231

Rice Yield

It is evident from the data (Table 4) that transplanting method of rice produced significantly higher grain yield. The highest grain yield of rice was found in transplanted rice (4404 kg ha^{-1}) followed by broadcast-biasi (3825 kg ha^{-1}) and direct seeded rice (3417 kg ha^{-1}). The higher straw yield was recorded in transplanting method (4975 kg $ha^{-1)}$ while the lower straw yield was recorded in direct seeded method (3904 kg ha^{-1}). The method of establishment plays an important role in growth, development and yield of rice. The proper and uniform density of plant stand under transplanting is the key to increase the grain yield of rice than direct seeding and broadcast biasi method of rice seeding. Puddling has great significance in rice establishment method because it facilitates in increasing the availability of nutrient, ensure better plant establishment and control of weed (Shukla *et al.* 2016; Gathala *et al* 2011; Samra and Dhillon, 2000) [17, 7, 13].

Acknowledgement

Sincere thanks to Dr. K. Tedia, HOD, Department of Soil Science and Agricultural Chemistry, Indira Gandhi Krishi Vishwavidyalaya, Raipur for providing facilities for conducting research.

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