Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; SP1: 638-641

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To study the different nutrient management and cropping system on soil microbial growth, production, rice equivalent yield and monetary returns in different rice based cropping systems

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Abstract
A field experiment was conducted during 2010-11 to 2012-13 at Jabalpur, Madhya Pradesh (India) to study the effect of nutrient management and cropping system on productivity and soil microbial growth under different rice based cropping systems in Madhya Pradesh. The 4 different cropping systems (CS1 Green manuring sunhemp-Rice-Wheat, CS2-Rice-Chickpea- Sesame, CS3-Rice-Berseem, CS4-Rice-Veg. pea-Sorghum) and three nutrient managements M1- 100% Organic(1/3 N through each of FYM, Vermicompost and Neem oil cake), M2 -100% Inorganic (100% NPK through fertilizers), M3-INM (50% NPK through fertilizer + 50% N through organic sources) with 3 replications in Strip plot design. The soil of the experimental field was sandy clay loam in texture, neutral in reaction (7.3), normal EC (0.52), low in OC (0.72%), medium in available N (264.05kg/ ha) and P(12.8 kg/ha) and high in K (285.2 kg/ha). The growth of bacteria (48.80 × 105), fungi (41.65 × 103), azatobacter (25.67 × 103), actinomycetes (13.55 × 103) and phosphorous solublizing bacteria (16.65 × 103) cfu g-1 soil was maximum in 100% inorganic nutrient management in rice berseem cropping system during the experiment and improved the rice equivalent yield of this cropping system.

Keywords: Cropping systems, economic status, agronomic management, soil quality, yield

Introduction
Rice and wheat are grown in a sequence on an area about 2.7 million hectares in Punjab and contribute 80% in the total food pool of the state of Punjab (DAGP, 2011) [2]. Madhya Pradesh is relatively underdeveloped with regards to agricultural productivity rural employment and economic status as compared to most of the Indian states. With the development of agricultural production, fertilization has been widely used as a common management practice to maintain soil fertility and crop yields (Shen, 2010) [5]. Long-term field experiments using different agronomic management can provide direct observations of changes in soil quality and fertility and can be predictions of future soil productivity and soil environment interactions. Over past decades, a great number of long-term experiments were initiated to examine the effects of fertilization on soil fertility in the world. Some studies have documented that the use of fertilizers was necessary and that continuous fertilizer application increased the concentrations of soil organic carbon, total nitrogen and other nutrients in plough layers compared with the initial value at the beginning of the experiment (Huang *et al*., 2010) [4]. Manure amendments markedly increased the contents of soil organic carbon, total nitrogen and other available nutrients and reduced soil acidification (Li *et al*., 2011). However, other studies have shown that the continued use of fertilizers may result in the decline of soil quality and productivity (Kumar *et al*., 2001). Long-term application of fertilizer helps to maintain the growth of micro organism growth in soil in rice-wheat cropping system (Bahadur *et al*., 2012) [1].

Materials and Methods
The present study was conducted during 2010-11 to 2012-13 at the Research Farm of Jawaharlal Nehru Krishi Vishwa Vidhyalaya, Jabalpur (M.P.), India on a sandy clay loam soil. The soil of the experimental site had a pH 7.4, EC 0.51 dS/m and organic carbon 0.7%. The available soil nitrogen, phosphorus and potash were 264, 12.6 and 282 kg/ha, respectively. The bulk density of the soil was 1.35 Mg/m3. The factors studied included 3 nutrient management practices *viz.*, 100% organic (NM1), 100% inorganic (NM2) and integrated nutrient (NM3) and 4 cropping systems *viz.*, CS1 green manuring- ricedurum wheat, CS2- rice-chickpea-sesame, CS3- riceberseem (fodder + seed), CS4 - rice-vegetable peasorghum (fodder) in strip plot design with 3 replication. The crop varieties grown were Pusa sugandha Basmati- 5 in rice, MPO-1106 in durum wheat, JG-24 for gram, JB-1 for berseem, Arkel for vegetable pea.

during winter season and TKG-55 in sesame and MP Chari in sorghum during summer season. These crops were raised with recommended agronomic practices. In organic manure treatment nutrients were applied through farm yard manure. The manure was applied on the nitrogen equivalent basis for each crop. The nutrient composition of FYM was 0.5, 0.25, 0.5% N, P2O5 and K2O respectively. For the weed management, mechanical measures were adopted and for insect pest management, neem oil (Azadiractin 0.03%) was applied as and when required under organic nutrient management. In chemical fertilizer treatment, nutrient was applied through chemical fertilizers *viz.*, urea, and single super phosphate muriate of potash while plant protection was done through recommended pesticides, when required. The recommended dose of fertilizers for rice, wheat, chickpea, sesame, vegetable pea, sorghum and berseem. 120:26.4:33.3, 120:26.4:33.3, 20:60:30, 30:60:30, 20:26.4:16.6, 100:22:25 and 20:26.4:16.6 kg N: P: K/ha.

Results and Discussion

Effect on total bacterial count

The microbial population of the experimental soil accelerated upon receiving nutrients either through chemical fertilizer, organic manure or integrated nutrient management (table 1). The population of total bacteria ranged from 42.06 × 105 to 45.50 × 105 cfu g-1 soil. Significant increase in bacterial population was recorded under 100% inorganic NM2 plots. As such maximum population of total bacterial count was observed in 100% inorganic NM2 (48.10, 48.06 and 47.10 × 105 cfu g-1 soil) followed by integrated NM3 (46.23, 46.10 and 45.98×105 cfu g-1 soil) during three the years. The population of total bacterial count was minimum (45.90, 45.60 and 44.70 × 105 cfu g-1 soil) in 100% organic NM1, respectively. The growth of total bacterial count was influenced by different cropping systems. The maximum growth of total bacterial count was observed in CS3 rice-berseem cropping system (46.88 and 46.90 × 105 cfu g-1 soil) followed by all other treatments. The growth of total bacterial count was similar in rice-vegetable pea-sorghum CS4, green manuring-rice-wheat cropping system CS1 and rice-chickpea-sesame cropping system CS2 and did not showed marked difference. Therefore, in this treatment the population of bacteria was improved over initial.

Effect on fungi

Growth of fungi was significantly affected due to different nutrient management practices during both the years. It was observed that when the plots were applied with 100% inorganic NM2 the population of fungi was maximum (41.62, 41.32 and 40.80 × 103 cfu g-1 soil). Whereas, similar growth of fungi was observed in integrated NM3 and 100% organic NM1 during three the years. The different cropping showed remarkable decrease in population of fungi during three the years. The maximum growth of fungi was observed in (41.89, 42.10 and 42.38 × 103 cfu g-1 soil) CS3 rice berseem cropping system which was at par to all other treatments. The other cropping systems CS4, CS1 and CS2 did not marked any significant differences. The minimum growth of fungi was observed under CS2 rice-chickpea-sesame cropping system (37.96, 37.25 and 38.40 × 103 cfu g-1 soil).On an average the growth was more during second year as compared to first year but more as compared to initial.

Effect on azatobacter

The nutrient management did not recorded much effect on growth of azatobacter. Whereas, maximum population of azatobacter was observed under 100% inorganic NM2 (25.42, 25.55 and 25.67 × 103 cfu g-1 soil), which was followed by integrated NM3 (25.05, 25.16 and, 25.19 × 103 cfu g-1 soil). The minimum growth of azatobacter was observed in 100% organic NM1 (23.24, 23.29 and 23.45 × 103 cfu g-1 soil) during three years which was more than initial value. The rice-berseem cropping system CS3 recorded the maximum growth of azotobacter (25.10, 25.50 and 25.62 × 103 cfu g-1 soil) which was superior over all other cropping systems but similar to CS4 rice-vegetable pea sorghum (25.09, 25.42 and 25.55 × 103 cfu g-1 soil). The CS1 and CS2 system had relatively similar growth of azotobacter.

Effect on actinomycetes

The actinomycetes showed adverse effect on its population due to different nutrient management practices. The maximum population of actinomycetes was observed in 100% inorganic NM2 (13.25, 13.48 and 13.55 × 103 cfu g-1 soil) during three years. Whereas, its growth decreased in other nutrient management practices NM3 and NM1. The maximum population of actinomycetes was observed in CS3 rice-berseem cropping system (13.52, 13.66 and 13.76 × 103 cfu g-1 soil). Minimum growth of actinomycetes was observed in CS2 rice-chickpea-sesame cropping system (11.12, 11.38 and 11.48 × 103 cfu g-1 soil).

Effect on PSB

The PSB showed adverse effect on its population due to different nutrient management practices. The maximum population of actinomycetes was observed in 100% inorganic NM2 (16.65, 16.50 and 16.12 × 103 cfu g-1 soil) during three years. Whereas, its growth decreased in other nutrient management practices NM3 and NM1. The maximum population of actinomycetes was observed in CS3 rice-berseem cropping system (16.19, 16.68 and 16.82 × 103 cfu g-1 soil). Minimum growth of actinomycetes was observed in CS2 rice-chickpea-sesame cropping system (15.12, 15.58 and 14.72 × 103 cfu g-1 soil).

Effect on rice equivalent yield

The growth of different soil micro organisms showed remarkable influence on yield of different crops. Thus due to this the yield of different crops was influenced under different nutrient management and cropping systems. The maximum rice equivalent yield was observed in 100% inorganic NM2 (68.85 q ha-1), which was at par to integrated NM3 (66.20 q ha-1) and 100% organic NM1 (60.30 q ha-1). The maximum rice equivalent yield was obtained in rice-berseem cropping system CS3 (77.82 q ha-1) and minimum in CS2 ricechickpea- sesame cropping system (51.08 q ha-1). And the yield in CS4 and CS1 were more than CS2.

Effect on production efficiency

The production efficiency of 100% inorganic nutrient management was the maximum (23.12 kg ha-1 day-1) which was at par with INM (21.16 kg ha-1 day-1) and 100% organic nutrient management (18.87 kg ha-1 day-1). The rice-berseem cropping system recorded the higher production efficiency of (26.45 kg ha-1 day-1) followed by rice-vegetable pea-sorghum (21.06 kg ha-1 day-1), green manuring-rice-wheat (20.78 kg ha-1 day-1) and rice-chickpea-sesame (15.74 kg ha-1 day-1) as also reported by (Shah *et al.* 2013) and (Upadhyay *et al.* 2011) [7].

Effect on gross monetary return

Out of 3 nutrient management practices 100% organic nutrient management fetched the highest gross monetary return of 168532 Rs ha-1 year-1, which declined as 162710 and 151576 Rs ha-1 year-1 due to 100% inorganic nutrient management and integrated nutrient management as on required as given in table 3. Among the 4 cropping system tested, rice-chickpea-sesame cropping system led to record the lowest gross monetary return (132403 Rs ha-1 year-1), which increased as 149722, 171983 and 189649 Rs ha-1 year-1 with rice-vegetable pea-sorghum (fodder) cropping system, green manuring-rice-wheat cropping system and rice-berseem (fodder+seed) cropping system, respectively. While considering the effect of treatment combinations rice-berseem (fodder+seed) cropping system with 100% organic nutrient management led to record maximum gross monetary return of 189649 Rs ha1 year-1, but it was minimum (132403 Rs ha-1 year-1) under rice-chickpeasesame cropping system with integrated nutrient management. The nutrient management and cropping system effected the growth of micro organisms and it ultimately resulted in increasing the crop yield in different cropping systems. Therefore, it can be concluded that application of 100% organic nutrient management in riceberseem (fodder+seed) cropping system was superior over all other treatments. It also resulted in better growth of microbes in soil.

Table 1: To study the nutrient management and cropping system on microbial population in soil after harvest and rice equivalent yield (mean of three years)

Treatments	Total bacterial count (105 × cfu g-1 soil)			Fungi (105 × cfu g-1 soil)			Azatobacter (103 x cfu g-1 soil)		
	2010-11	2011-12	2012-13	2010-11	2011-12	2012-13	2010-11	2011-12	2012-13
Nutrient Management									
NM1-100% organic (1/3 N through each of FYM, Vermicompost and Neem oil cake)	45.90	45.60	44.70	40.72	40.52	40.15	23.24	23.29	23.45
NM2-100% Inorganic (100% NPK through fertilizers)	48.10	48.06	47.10	41.65	41.32	40.80	25.42	25.55	25.67
NM3-Integrated Nutrient Management (50% NPK through fertilizer + 50% N through organic sources)	46.23	46.10	45.98	41.02	40.98	40.67	25.05	25.16	25.19
SEm±	1.65	1.60	1.62	1.64	1.60	1.69	0.85	0.92	0.68
CD(P=0.05)	4.80	4.77	4.15	4.88	4.52	4.32	2.27	2.18	2.08
Mean	46.74	46.59	45.93	41.13	40.94	40.54	24.57	24.67	24.77
Cropping System									
CS1-Green manuring (sunhemp)- rice (Pusa Sugandha 5)- wheat (MPO 1106)	42.48	42.55	42.72	37.92	38.62	38.70	23.55	23.92	24.01
CS2-Rice (Pusa Sugandha 5)- chickpea (JG 322)-sesame (TKG 55)	42.06	42.22	42.28	37.96	38.25	38.40	23.35	23.72	23.85
CS3-Rice (Pusa Sugandha 5)-berseem (JB 5) (fodder+seed)	46.72	46.92	47.00	41.89	42.10	42.38	25.10	25.50	25.62
CS4-Rice (Pusa Sugandha 5)-vegetable pea (Arkel)-sorghum (MP Chari) (fodder)	45.49	45.62	45.69	40.60	41.05	41.12	25.09	25.42	25.55
SEm±	1.61	1.70	1.52	1.52	1.66	1.67	0.52	0.69	0.62
CD(P=0.05)	4.92	5.00	4.62	4.85	4.74	4.55	1.65	1.97	1.88
Mean	44.19	44.33	44.42	39.59	40.01	40.15	24.27	24.64	24.76

Table 2: To study the nutrient management and cropping system on microbial population in soil after harvest and rice equivalent yield (mean of three years)

Treatments	Actinomycetes (103 x cfu g-1 soil)			PSB (103 x cfu g-1 soil)			Rice equivaent yield (qha^{-1})	production efficiency (kg ha-1 day-1)
	2010-11	2011-12	2012-13	2010-11	2011-12	2012-13		
Nutrient Management								
NM1-100% organic (1/3 N through each of FYM, Vermicompost and Neem oil cake)	11.68	11.62	11.70	14.82	14.53	14.09	60.30	18.87
NM2-100% Inorganic (100% NPK through fertilizers)	13.25	13.48	13.55	16.65	16.50	16.12	68.85	23.12
NM3-Integrated Nutrient Management (50% NPK through fertilizer + 50% N through organic sources)	12.35	12.55	12.69	15.40	15.60	13.72	66.20	21.16
SEm±	0.96	0.87	0.58	0.67	0.63	0.72	2.19	0.41
CD(P=0.05)	2.14	2.14	1.49	1.59	1.74	1.84	9.02	0.98
Mean	12.43	12.55	12.65	15.62	15.54	14.64	65.12	21.05
Cropping System								
CS1-Green manuring (sunhemp)- rice (Pusa Sugandha 5)- wheat (MPO 1106)	11.09	11.55	11.72	15.22	15.40	15.50	60.85	20.78
CS2-Rice (Pusa Sugandha 5)- chickpea (JG 322)-sesame (TKG 55)	11.12	11.38	11.48	15.12	15.58	14.72	51.08	15.74
CS3-Rice (Pusa Sugandha 5)-berseem (JB 5) (fodder+seed)	13.52	13.66	13.76	16.19	16.68	16.82	77.82	26.45
CS4-Rice (Pusa Sugandha 5)-vegetable pea (Arkel)-sorghum (MP Chari) (fodder)	12.35	12.48	12.62	14.08	14.50	15.62	69.02	21.06
SEm±	0.82	0.80	0.98	1.02	1.07	1.24	8.92	2.42
CD(P=0.05)	2.08	2.19	2.35	2.48	2.78	2.83	22.6	6.15
Mean	12.02	12.27	12.40	15.15	15.54	15.67	64.69	21.01

Table 3: To study the different nutrient management and cropping systems on mean gross monetary returns (Rs ha^{-1} $year^{-1}$).

Treatments	CS1-Green manuring- rice-wheat	CS2-Rice - chickpea- sesame	CS3-Rice-berseem (fodder+seed)	CS4-Rice-veg. pea-sorghum (fodder)	Mean
NM1 100% organic (1/3 N through each of FYM, Vermicompost and Neem oil cake)	181914	137823	195423	158968	168532
NM2 100% Inorganic (100% NPK through fertilizers)	172549	134556	193657	150076	162710
NM3 Integrated Nutrient Management (50% NPK through fertilizer + 50% N through organic sources)	161487	124829	179867	140122	151576
Mean	171983	132403	189649	149722	

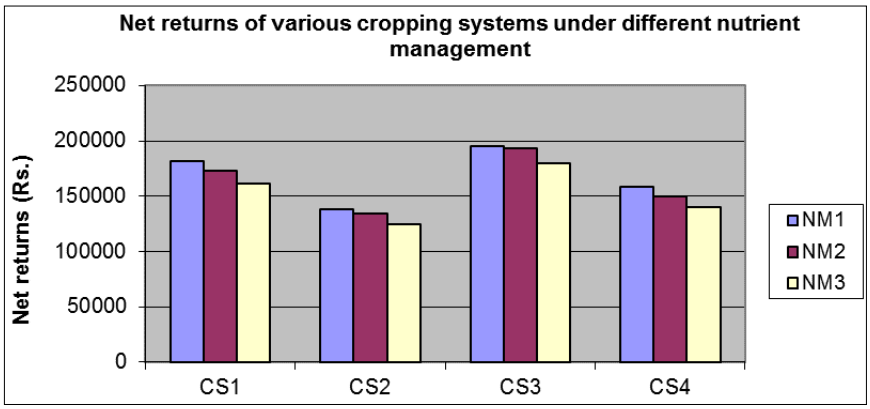

Fig 1

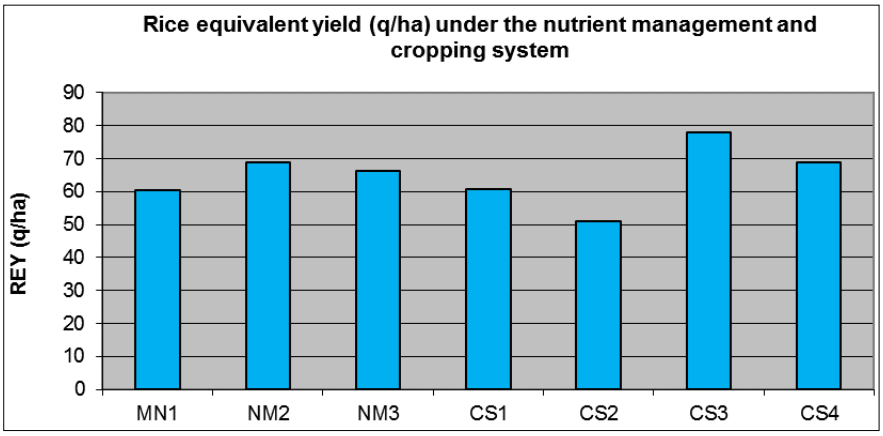

Fig 2

Conclusion

The nutrient management and cropping system effected the growth of micro organisms and it ultimately resulted in increasing the crop yield in different cropping systems. Therefore, it can be concluded that 100% inorganic NM2 in rice-berseem cropping system CS3 was superior over all other treatments.

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