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EFFECT OF PUDDLING, IRRIGATION AND NUTRIENT SOURCES ON YIELD, NUTRIENT UPTAKE BY RICE AND SOIL MOISTURE STATUS UNDER SUB-TROPICAL CONDITION OF JAMMU

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ABSTRACT

A field experiment was conducted at the research farm, FOA, Main campus, Chatha of SKUAST-Jammu during kharif seasons of 2005 and 2006. The experiment with 36 treatment combinations was laid out in split plot design where in main plots consisted of different puddling intensities and three levels of irrigation scheduling on which four nutrient sources were superimposed as sub plots. Three times puddling was found to increase the number of tillers (322.50 and 334.39 sq m^{-1}), grain weight $panicle^{-1}$ (1.96 and 1.98 g) 1000 grain weight (21.81 and 21.99 g), grain (43.72 and 45.34 q ha^{-1}) and straw yield (64.01 and 66.09 q ha^{-1}) significantly over normal practice. Irrigation at soil matric potential (SMP) of 150 cm suction gave significantly higher number of tillers (320.39 and 331.19 sq m^{-1}), grain weight $panicle^{-1}$ (1.99 and 2.00 g), 1000 grain weight (21.61 and 22.25 g), grain (43.73 q ha^{-1}) and straw yield (64.10 q ha^{-1}) of rice than irrigation at 2 and 4 DADPW, respectively during both the years, Similarly application of N through FYM or vermicompost coupled with inorganic fertilizer or alone 6 t vermicompost ha^{-1} also increased the number of tillers (311.04 and 336.41 sq m^{-1}), grain weight $panicle^{-1}$ (1.92 and 2.01 g), 1000 grain weight (21.34 and 22.31 g), grain yield (45.56 q ha^{-1}) and straw yield (66.57 q ha^{-1}) of rice. Irrigation SPM 150 cm suction showed higher moisture in all the soil profile depth than irrigation at 2 and 4 DADPW. Similarly application of 6 t vermicompost ha^{-1} also increased the moisture content in all the depths of soil profile. Irrigation scheduling and nutrient sources significantly increased the N, P and K uptake by rice crop.

Keywords: Puddling, irrigation, nutrients, yield, uptake, rice, soil moisture.

INTRODUCTION

In Jammu and Kashmir rice covers an area of about 259.4 thousand hectare with an production of 497.4 thousand tonnes and average yield of 19.14 q ha^{-1} which is less as compared to national average of rice, i.e. 21.02 q ha^{-1} (Anonymous, 2011). It happens due to application of imbalanced use of chemical fertilizer as well as faulty management of irrigation practices especially in rice crop. Decreasing water resources and increasing water costs necessitates increasing water use efficiency for rice. The most common method of irrigation in north western India is through alternate wetting and drying with a fixed irrigation interval, irrespective of soil type and climatic demand resulting in over-irrigation or under-irrigation under different soil and weather situations. Soil matric potential may be an ideal criterion for irrigation. Application of organic materials in conjunction with inorganic fertilizers in the crops increased productivity and soil health thereby leading to sustainability of the ecosystem besides benefiting the succeeding crop owing to the build up of soil organic carbon content (Luikham *et al.*, 2004, Thakur *et al.*, 2010). Optimum water management in rice on the basis of appropriate irrigation scheduling and puddling intensities are of practical relevance and need of hour (Hira, 2009). Henceforth, the present study was conducted with a view to find out the optimum combination of organic (Vermicompost and FYM) and inorganic sources of nutrients for rice cultivation with different puddling and irrigation levels under sub-tropical conditions of Jammu.

MATERIALS AND METHODS

A field experiment was conducted during the *kharif* season of 2005 and 2006 at the Research Farm, Main Campus, Chatha of SKUAST-Jammu. The soil of the experimental field was sandy loam in texture, neutral to slightly alkaline in reaction (pH 7.4), low in organic carbon (4.6 kg^{-1}) and available N (212 kg ha^{-1}) and medium in available P (15.9 kg ha^{-1}) and K (139.0 kg ha^{-1}). The experiment was laid out in split plot design with three replications. The treatments consisted of 3 levels of puddling i.e. normal practice (1 time), 2 times puddling and puddling thrice with 3 levels of irrigation schedule i.e. 2 days after disappearance of ponded water (DADPW), 4 DADPW and irrigation at soil matric potential (SMP)

at 150 cm suction as main plots and 4 levels of nutrient sources i.e. 3 t vermicompost ha^{-1} + 75% recommenced dose of NPK through inorganic fertilizers, 6 t vermicompost ha^{-1}, 50% N through FYM + 50% NPK through inorganic fertilizers and recommended N, P, K doses through inorganic fertilizer) as sub plots. Rice 'PC-19' was transplanted with seedlings of 25 days old at a spacing of 20x15cm. The organic sources like vermicompost (N-3 %, P-0.6 % and K-1.3 %) and FYM (N-0.61 %, P-0.22 % and K-0.72 %) were incorporated on dry weight basis 5 days before transplanting in the respective treatments. Recommended dose of N: P_2O_5: K_2O @ 100:60:60 kg ha^{-1} wherein full dose of recommended P through DAP and K through MOP besides half dose of N through urea were applied as basal dose at the time of sowing and rest of the N was given in two equal splits as top dressing at mid tillering and before panicle emergence stage. Irrigation was recorded with the help of permanently fixed scales on Parshall flume, water depth before and after each irrigation was recorded and the difference was taken as the amount of applied irrigation. Irrigation scheduling in rice was carried out mainly on the basis of disappearance of ponded water at an interval of 2-6 days after complete infiltration of water besides on the basis of soil matric potential at 150 $\pm$ 20 cm suction through the use of permanently fitted tensiometers during the crop growing season. Number of tillers per meter square, grain weight of five randomly selected panicles was taken as average grain weight per panicle (g), out of which 1000 grains were counted and weighed as test weight (g), net plot area was harvested, sun dried for 3-4 days and was subsequently threshed and cleaned. The grains thus obtained, were weighed and expressed in q ha^{-1}, the straw yield was computed by deducting the net plot grain yield from net plot bundle weight and expressed as q ha^{-1}. Plant (grain and straw) samples collected at harvest were digested and analysed for P and K by using standard method and N by modified Kjeldhal's method (Jackson, 1973). Soil moisture content after harvest of rice was determined gravimetrically by drying the samples in oven at 105°C till constant weight. The moisture storage under different puddling and irrigation in different layers of 0-30, 30-60 and 60-90 cm of root zone was computed by following formula:

$$M = \sum_{I=1}^{n} \frac{Mpi}{100} \times Dbi \times Di$$

Where,

M = Amount of moisture in 0 to 90 cm soil profile

$\sum_{I=1}^{n}$ = Summation of water content of n number of soil layers varied from 1 to nth layer

Mpi = Moisture percent of i^{th} layer

Dbi = Bulk density of i^{th} layer in Mg m^{-3}

Di = Depth of i^{th} layer of soil in cm

RESULTS AND DISCUSSION

Yield and Yield Attributes

Three times puddling was found to increase in number of tillers (322.50 and 334.39 sq m^{-1}), grain weight $panicle^{-1}$ (1.96 and 1.98 g) 1000 grain weight (21.81 and 21.99 g), grain (43.72 and 45.34 q ha^{-1}) and straw yield (64.01 and 66.09 q ha^{-1}) significantly during first and second year, respectively as compared to normal practice of puddling and 2 times puddling (Table-1). The increase in the yield may be due to better water retention capacity of the soil due to better puddling of the soil thus making the soil impervious to water besides soft bed for easy establishment of the rice seedlings and reduction of vegetative lag phase resulting in better growth and favourable environment for root proliferation. Application of irrigation at soil matric potential (SMP) of 150 cm suction gave significantly higher number of tillers (320.39 and 331.19 sq m^{-1}), grain weight $panicle^{-1}$ (1.99 and 2.00 g), 1000 grain weight (21.61 and 22.25 g), grain (43.73 q ha^{-1}) and straw yield (64.10 q ha^{-1}) of rice than irrigation at 2 and 4 DADPW respectively during first year. However, both were at par with the irrigation applied at 2 DADPW during the second year which may be attributed to the increased water infiltration and water retention owing to use of vermicompost as a nutrient source due to which the increased organic matter during the second year may have shown better water retention capacity and water use efficiency. Moreover, the irrigation applied through SMP at 150 cm suction may have provided the constant and proper water required for mobilizing the constant nutrient supply which in turn might have helped to promote the metabolic activity of the plant. The results corroborate the findings of Hira (2009).

Application of N, P and K at recommended level brought significant increase in the number of tillers (324.66 and 317.59 sq m^{-1}), grain weight $panicle^{-1}$ (1.98 and 1.93 g) 1000 grain weight (22.02 and 21.54 g), grain (43.64 q ha^{-1}) and straw yield (64.50 q ha^{-1}) of rice than 3 t vermicompost ha^{-1} + inorganic fertilizers, 3 t vermicompost ha^{-1} alone and FYM + inorganic fertilizers (50% each) at harvest in the first year.

Table 1: Yield and yield attributes of rice crop as influenced by various treatments

Treatments	No. of tillers (sq m^{-1})		Grain weight $panicle^{-1}$ (g)		1000-grain weight (g)		Grain yield (q ha^{-1})		Straw yield (qha^{-1})	
	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
Puddling intensity										
Normal practice	314.72	324.97	1.94	1.96	21.59	21.77	41.94	43.60	60.76	62.83
2-times puddling	315.83	326.08	1.95	1.97	21.69	21.87	42.52	44.15	61.80	63.88
3-times puddling	322.50	334.39	1.96	1.98	21.81	21.99	43.72	45.34	64.01	66.09
C.D. (p=0.05)	2.53	2.82	N.S	N.S	N.S	N.S	0.44	0.41	0.67	0.60
Irrigation scheduling										
2 DADPW*	317.69	328.47	1.95	1.97	21.37	21.96	42.39	44.04	61.27	63.67
4 DADPW	314.97	325.78	1.92	1.94	21.12	21.42	42.07	43.69	61..21	62.96
SMP** at 150 cm suction	320.39	331.19	1.99	2.00	22.61	22.25	43.73	45.35	64.10	66.17
C.D. (p=0.05)	2.53	2.82	0.06	0.10	0.63	0.69	0.44	0.41	0.67	0.60
Nutrient sources										
Vermicompost 3t ha^{-1}+inorganic fertilizer	314.00	325.93	1.94	1.94	21.52	21.83	42.51	44.06	61.45	63.53
Vermicompost @ 6t ha^{-1}	311.04	336.41	1.92	2.01	21.34	22.31	41.75	45.56	59.91	66.57
FYM+In-organic fertilizer (50% each)	321.04	334.00	1.97	1.99	21.90	21.85	43.02	44.77	62.91	64.98
R D of NPK	324.66	317.59	1.98	1.93	22.02	21.54	43.64	43.05	64.50	61.99
C.D. (p=0.05)	3.86	4.87	0.04	0.09	0.59	0.63	0.43	0.46	1.20	0.88

**Days after disappearance of ponded water, ** Soil matric potential*

However, during second year, application of 6 t vermicompost ha^{-1} increased the number of tillers (311.04 and 336.41 sq m^{-1}), grain weight $panicle^{-1}$ (1.92 and 2.01 g), 1000 grain weight (21.34 and 22.31 g), grain yield (45.56 q ha^{-1}) and straw yield (66.57 q ha^{-1}) over 3 t vermicompost ha^{-1}+ inorganic fertilizer (44.06 q ha^{-1}), FYM + inorganic fertilizers (50% each) (44.77 q ha^{-1}) and N, P and K applied through inorganic fertilizers (43.05 q ha^{-1}). This may be due to the mineralization of the applied vermicompost during previous and subsequent year which may have added essential micronutrients so as to improve the soil physico-chemical properties besides releasing macro nutrients in optimum doses and other growth promoting substances, which influenced the availability of major and minor nutrients, thereby resulting in higher grain yield and yield attributes of rice. The results corroborate with the findings of Singh (2006) Thakur *et al.* (2010), Singh *et al.* (2011).

Uptake studies

Irrigation scheduling and nutrient sources significantly increased the N, P and K uptake of rice crop, but no significant difference was observed with different levels of puddling on the uptake of nutrients in rice (Table 2). However nutrient uptake (grain & straw) of N (100.8 and 101.6 kg ha^{-1}), P (18.7 and 19.1 kg ha^{-1}) and K (107.3 and 107.6 kg ha^{-1}) by rice crop during 1st and 2nd year of study increased significantly with application of irrigation SMP at 150 cm suction though at par with irrigation at 2 DADPW. Total uptake of N, P, and K (101.6 kg ha^{-1}, 18.8 kg ha^{-1} and 108.1 kg ha^{-1}) by rice crop was recorded higher under recommended dose of N, P and K applied through fertilizers during 2005-06 whereas significant increase in total nutrients (grain and straw) uptake of N (102.0 kg ha^{-1}), P (19.2 kg ha^{-1}) and K (107.3 kg ha^{-1}) was observed during 2006-07 with application of 6 t vermicompost ha^{-1} alone over 50% N through FYM + 50% NPK through inorganic fertilizer and 3 t vermicompost ha^{-1}+ inorganic fertilizer. This may be attributed to enhanced availability of nitrogen with vermicompost and inorganic nutrients in the irrigation regimes whereas increase in P uptake, because of conversion of ferric phosphate to ferrous phosphate and by forming the phospho-humic complexes which are easily assimilated by the crop. Similar findings were also reported by Balasubramanian and Krishnarajan (2000), Balamurugan and Sudhakar (2012) and Singh *et al.* (2013).

Soil moisture

Soil moisture increased with the depth of soil profile up to 90 cm and all the treatments have differential effect on the soil moisture status after the harvest of rice crop (Table 2). Soil moisture content in the soil profile at 60-90 cm depth was recorded more as compared with soil moisture at 0-15, 15-30 and 30-60 cm depths of soil profile. Similarly 3 times puddling increased the soil moisture (6.30 and 6.66 %) at 0-15 cm, (7.00 and 7.27%) at 15-30 cm, (8.45and 8.48%) at 30-60 cm and (8.49 and 8.51%) at 60-90 cm depth than 2 times puddling and normal practice. Application of irrigation at SMP 150 cm suction resulted in higher soil moisture status 6.01 and 6.50% at 0-15 cm, 6.71 and 7.11% at 15-30 cm,

Table 2: Pattern of soil profile moisture and nutrient uptake by rice crop as affected by different treatments

Treatments	Soil profile (cm)								Nutrient uptake (kg ha^{-1})					
	2005				2006				2005			2006		
	0-15	15-30	30-60	60-90	0-15	15-30	30-60	60-90	N	P	K	N	P	K
Puddling intensity														
Normal practice	5.24	5.94	8.39	8.43	6.20	6.81	8.42	8.45	100.2	18.6	106.4	101.1	19.0	106.8
2-times puddling	6.10	6.21	8.42	8.46	6.43	7.04	8.45	8.48	100.4	18.6	107.2	101.2	19.0	107.6
3-times puddling	6.30	7.00	8.45	8.49	6.66	7.27	8.48	8.51	100.8	18.7	107.3	101.6	19.1	107.6
C.D. (p=0.05)									N.S	N.S	N.S	N.S	N.S	NS
Irrigation scheduling														
2 DADPW*	5.96	6.66	8.22	8.26	6.56	7.17	8.25	8.28	101.0	18.7	107.5	101.8	19.1	107.8
4 DADPW	5.67	6.37	8.49	8.53	6.23	6.84	8.52	8.55	99.2	18.4	106.4	100.0	18.8	106.8
SMP** at 150 cm suction	6.01	6.71	8.55	8.59	6.50	7.11	8.50	8.61	101.3	18.7	107.7	102.0	19.1	108.0
C.D. (p=0.05)									1.0	0.1	1.1	1.2	0.3	1.0
Nutrient sources														
Vermicompost 3t ha^{-1}+inorganic fertilizer	5.74	6.44	8.39	8.42	5.91	6.52	8.41	8.43	100.1	18.6	106.9	100.4	18.8	107.1
Vermicompost @ 6t ha^{-1}	6.17	6.87	8.60	8.69	7.54	8.15	8.66	8.72	99.4	18.5	106.3	102.0	19.2	107.3
FYM+In-organic fertilizer (50% each)	5.94	6.64	8.52	8.58	6.99	7.50	8.56	8.59	100.7	18.7	107.4	101.7	19.2	107.9
R D of NPK	5.66	6.36	8.16	8.17	5.30	5.61	8.17	8.17	101.6	18.8	108.1	101.0	18.9	107.9
C.D. (p=0.05)									0.8	0.1	0.9	0.9	0.1	1.0

**Days after disappearance of ponded water, ** Soil matric potential*

8.55 and 8.50% at 30-60 cm and 5.59 and 8.61% at 60-90 cm depth of soil profile than irrigation at 2 and 4 DADPW, Application of 6 t vermicompost ha^{-1} alone also increased the moisture content in all the depths of soil profile. The results are in conformity with the findings of Singh (2006).

It is concluded that three times puddling intensity with irrigation scheduling at soil matric potential of 150 cm suction increased the grain and straw yield of rice, nutrient uptake and soil moisture at various depths, similarly application of N through FYM or vermicompost coupled with inorganic fertilizers or alone 6 t vermicompost ha^{-1} increased the yield attributes, yield, soil moisture and nutrient uptake of rice.

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