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

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; 6(5): 1063-1066
Received: 05-07-2017
Accepted: 07-08-2017

M Eshwar
Department of Soil Science and Agricultural Chemistry, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad, India

M Srilatha
Department of Soil Science and Agricultural Chemistry, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad, India

K Bhanu Rekha
Department of Agronomy, Agriculture College, Palem, Nagarkurnool, India

S Harish Kumar Sharma
Department of Soil Science and Agricultural Chemistry, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad, India

Correspondence
M Eshwar
Department of Soil Science and Agricultural Chemistry, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad, India

Effect of humic substances (humic, fulvic acid) and chemical fertilizers on nutrient uptake, dry matter production of aerobic rice (*Oryza sativa* L.)

M Eshwar, M Srilatha, K Bhanu Rekha and S Harish Kumar Sharma

Abstract
The pot culture experiment was conducted in green house, college of agriculture during *kharif* 2016 to study the effect of humic substances and chemical fertilizers on nutrient uptake, dry matter production of aerobic rice (*Oryza sativa* L.). Humic and fulvic acid was applied along with iron as Fe-fulvate and Fe-humate in 1:1.5 molar ratio along with Fe-chelate and $FeSo_4$ @ 2.5 mg/kg as soil application and 0.25% as foliar application at vegetative and panicle initiation stage with recommended dose of fertilizers. The results concluded that nutrient uptake, dry matter production was increased with foliar application of $FeSo_4$ @ 0.25% at vegetative and panicle initiation stage among other imposed treatments.

Keywords: humic acid (HA), Fulvic acid (FA), Nutrient uptake, dry matter production.

Introduction
Rice (Oryza sativa L.) is the staple food grain crop in Asia Island. India is the second largest producer of rice next to china producing 106.54 mt with an average productivity of 2424 kg ha^{-1} from an area of 43.95 m ha. In Telangana rice is cultivated in 1.6 m ha with a production of 13.43 mt and an average productivity of 3330 kg ha^{-1} (India stat, 2014-15). Aerobic rice is a renewed way of growing rice in non-submerged unpuddled condition in aerated soils. It is grown like any other crops like maize or sorghum on dry soils with surface irrigations provided when necessary with intensive agronomic practices. Aerobic rice is projected as sustainable rice production methodology for the immediate future to address water scarcity and environmental safety in the scenario of global warming (www.aerobicrice.org). Aerobic rice requires less labour (55%) than low land puddle rice and can be mechanized (Wang *et al.*, 2002) [20]. Aerobic rice is an alternate system that requires less water and high external inputs (Bouman *et al.*, 2002) [3].
Micronutrients are essential for plant growth and play an important role in balance crop nutrition. Micronutrient deficiencies especially zinc and iron is considered as one of the major causes of the declining productivity trends observed in rice growing regions. The reduction of iron (Fe) availability with aerobic cultivation of rice is a serious problem because Fe is an essential nutrient for plants: Fe is required for respiration and photosynthesis. Insufficient Fe uptake leads to interveinal chlorosis in leaves and reduced yield (Terry, 1981) [16]. Iron deficiency is often a nutritional problem for crops in upland soils and is one of the primary limitations to rice production in aerobic areas (Barbosa and Yamasa 2002; Tuong and Bouman 2003) [2, 18]. Although the total amount of Fe in the rhizosphere soil is often 10,000 times greater than the Fe content of the plant itself, Fe deficiency is still common in agricultural production. This anomaly is due to low availability of Fe in the presence of oxygen, especially at moderate and high soil pH (Graham and Stangoulis 2003) [7]. It remains unclear how Fe nutrition of aerobic rice is affected by high pH caused by the shift from flooded to aerobic cultivation.
Application of humic substances in agriculture as fertilizer and soil conditioner were tried on limited scale. Significant impact of these humic substances on soil structure and plant growth was reported earlier by Ihsanullah and Bakhashawin (2013) [9]; El-Razek *et al.* (2012) [4] and Fong *et al.* (2007) [5]. HA in proper concentration can enhance plant and root growth (Ahmed *et al.*, 2013) [1] Humic substances (humic, fulvic acid) attracts positive ions, forms chelates with micronutrients and releases them slowly when required by plants. According to Kadam *et al.* (2010) [11] the humic substances act as chelating agents there by prevents formation of precipitation, fixation, leaching and oxidation of micronutrients in soil. The following research study was taken up to prevent the loss of micronutrients in aerobic rice.

Material and Methods

The pot culture experiment was conducted in green house conditions during *kharif* 2016 to study the effect of humic substances and chemical fertilizers on nutrient uptake, dry matter production of aerobic rice. An iron deficient inceptisol was used for pot culture experiment. Five kg of soil was filled in every pot. The soil used for pot culture having sandy loam texture with pH 7.75, EC 0.25 dS m^{-1}, organic carbon 0.45%, low available N 220 kg ha^{-1}, medium available P 22.5 kg ka^{-1}, medium available potassium 202.5 kg ha^{-1} and low in DTPA extractable iron 2.63 mg kg^{-1}. The variety used for pot culture was MTU-1010. The seeds were sown in pots to have five hills per pot. The fertilizer was applied at the rate of 180 kg N, 60 kg P_2O_5 and 40 kg K_2O per ha. Phosphorus and potash was applied as basal and nitrogen was applied in splits. The experiment was laid in completely randomized block design with 11 treatments T_1-Control, T_2-Fulvic acid, T_3-Humic acid, T_4- Soil application of Fe-chelate @ 2.5 mg Fe kg^{-1} soil, T_5- Soil application of Fe-fulvate @ 2.5 mg Fe kg^{-1} soil, T_6- Soil application of Fe-humate @ 2.5 mg Fe kg^{-1} soil, T_7- Soil application of $FeSO_4$ @ 2.5 mg Fe kg^{-1} soil, T_8- Foliar application of Fe-chelate @ 0.25% at vegetative stage and panicle initiation stage, T_9- Foliar application of Fe-fulvate @ 0.25% at vegetative stage and panicle initiation stage, T_{10}- Foliar application of Fe-humate @ 0.25% at vegetative stage and panicle initiation stage, T_{11}- Foliar application of $FeSO_4$ @0.25% at vegetative stage and panicle initiation stage.

The rice grown under pot culture in aerobic condition. Iron is major constraint in aerobic rice, to overcome this Fe is applied along with humic and fulvic acid as Fe-humate and Fe-fulvate by stability constants and found that 1:1.5 is suitable molar ratio. Plant samples collected at 30, 60 DAS and harvest were shade dried for 3-4 days, oven dried at 65^0C. A known quantity of plant sample was digested with triacid mixture (HNO_3:H_2SO_4: $HClO_4$) and analyzed for P, K and Fe and for N plant samples were digested with H_2SO_4. Nitrogen content of plant sample was estimated by adopting the modified microkjeldahl method (Jackson, 1973) [10]. Phosphorus content was determined by Barton's Reagent (Vanado molybdate reagent) phosphoric yellow colour method as described by Piper (1966) [13] using Spectrophotometer at 420 nm and expressed as per cent. The potassium content was determined using flame photometer (Piper, 1966) [13] and expressed as per cent. The iron content in plant samples was determined by using atomic absorption spectrophotometer (AAS) (Lindsay and Norwell, 1978) [12]. The nutrient uptake was calculated by using following formulas.

N uptake = N content (%) x Dry matter production (g pot^{-1})

P uptake = P content (%) x Dry matter production (g pot^{-1})

K uptake = K content (%) x Dry matter production (g pot^{-1})

Fe uptake (µg g^{-1}) = Fe content (µg g^{-1}) x Dry matter production (g pot^{-1})

Results and Discussion

The data pertaining to uptake of N, P and K at vegetative, panicle initiation and harvest stage of rice are furnished in the Table 1.

Nitrogen

In general, the nitrogen uptake increased with the advancement of the crop from vegetative stage to harvest stage *i.e.* from 24.11 g pot^{-1} to 51.96 g pot^{-1} (Table 1). At vegetative stage, highest nitrogen uptake 24.11 g pot^{-1} was recorded in the treatment T_{11} followed by T_7 18.63 g pot^{-1} which was on par with T_9 18.52 g pot^{-1} and lowest nitrogen uptake was recorded with application of RDF alone 2.83 g pot^{-1}. At panicle initiation stage the highest nitrogen uptake 31.34 g pot^{-1} was recorded in the treatment T_{11} followed by T_9 26.16 g pot^{-1} and T_{10} 21.74 g pot^{-1} which was on par with T_7 20.76 g pot^{-1} and lowest nitrogen uptake was recorded 4.48 g pot^{-1} with application of RDF alone. Similarly at harvest the highest nitrogen uptake 51.96 g pot^{-1} was recorded in the treatment T_{11} followed by T_9 43.36 g pot^{-1} and lowest nitrogen uptake 7.59 g pot^{-1} was recorded with application of RDF alone.

Phosphorus

In general the phosphorus uptake increased with the advancement of crop from vegetative to harvest stage 3.26 g pot^{-1} to 5.64 g pot^{-1} (Table 1). At vegetative stage highest phosphorus uptake was recorded in the treatment T_{11} 3.26 g pot^{-1} followed by T_7 2.74 g pot^{-1} which was on par with T_9 2.68 g pot^{-1} and lowest phosphorus uptake was recorded 0.53 g pot^{-1} with application of RDF alone. At panicle initiation stage highest phosphorus uptake was recorded in the treatment T_{11} 4.31 g pot^{-1} followed by T_9 3.66 g pot^{-1} which was on par with T_7 3.49 g pot^{-1} and lowest phosphorus uptake was recorded with application of RDF alone 0.80 g pot^{-1}. Similarly at harvest highest phosphorus uptake was recorded in the treatment T_{11} 5.64 g pot^{-1} followed by T_7 4.65 g pot^{-1} and lowest phosphorus uptake 1.16 g pot^{-1} was recorded with application of RDF alone.

Potassium

In general the potassium uptake increased with the advancement of crop from vegetative to harvest stage *i.e.* 15.72 g pot^{-1} to 47.81 g pot^{-1} (Table 1). At vegetative stage highest potassium uptake was recorded in the treatment T_{11} 15.72 g pot^{-1} followed by T_7 14.47 g pot^{-1} and lowest potassium uptake 3.71 g pot^{-1} was recorded with application of RDF alone. At panicle initiation stage highest potassium uptake 20.49 g pot^{-1} was recorded in the treatment T_{11} followed by T_7 17.66 g pot^{-1} which was on par with T_9 17.50 g pot^{-1} and lowest potassium uptake was recorded with application of RDF alone 5.06 g pot^{-1}. Similarly at harvest stage highest potassium uptake was recorded in the treatment T_{11} 47.81 g pot^{-1} followed by T_7 40.12 g pot^{-1} which was on par with T_9 38.66 g pot^{-1} and lowest potassium uptake 9.17 g pot^{-1} was recorded with application of RDF alone.

The above results indicated that among all the treatments imposed $FeSO_4$ showed higher nutrient N, P and K uptake by rice. This could be due to the increased solubility of Fe from $FeSO_4$ than that from Fe-complexes and higher availability to crop plants. Among humic substances, fulvic acid showed higher nutrient uptake over humic acid and this could be due to the formation of more soluble fulvic - metal complexes as fulvic acid is more soluble in water, whereas humic acid tend to produce more insoluble metal complexes. These results are in conformity with those of Gondar *et al.* (2006) [6].

Similarly Sathiyabama (2009) [14] also earlier reported increased nutrient uptake with increase in humic acid concentration due to the positive influence of these substances on protein and nucleic acid synthesis (Guminski, 1968) [8]. Humic acid also influence the plant growth directly either through its effect on ion uptake or by more effects on growth regulation of the plant (Vaughan and Linehan, 1976) [19].

Uptake of Fe

In general the iron uptake increased with advancement of crop from vegetative stage to harvest stage from 54.68 to 187.70 µg pot^{-1} (Table 1). At vegetative stage highest iron uptake 54.68 µg pot^{-1} was recorded in the treatment T_{11} followed by T_7 49.31µg pot^{-1} and lowest iron uptake 5.20 µg pot^{-1} was recorded with application of RDF alone. At panicle initiation stage highest iron uptake 80.23 µg pot^{-1} was recorded in the treatment T_{11} followed by T_7 64.04 µg pot^{-1} which was on par with T_9 62.63 µg pot^{-1} and lowest iron uptake 9.09 µg pot^{-1} was recorded with application of RDF alone. Similarly at harvest highest iron uptake 187.70 µg pot^{-1} was recorded in the treatment T_{11} followed by T_9 151.92 µg pot^{-1} which was on par with T_7 145.14 µg pot^{-1} and lowest iron uptake 24.73µg pot^{-1} was recorded with application of RDF alone.

Humic substances (humic acid) attracts positive ions, forms chelates with micronutrients and releases them slowly when required by plants. According to Kadam *et al.* (2010) [11] the humic substances act as chelating agents there by prevents formation of precipitation, fixation, leaching and oxidation of micronutrients in soil.

Dry matter production

Dry matter production is the expression of growth and development of different morphological components and it is directly related to the yield.

In general the dry matter production of rice crop increased from age of plants from vegetative to harvest stage *i.e.* from 15.25 g pot^{-1} to 21.42 g pot^{-1} respectively (Table 1). At vegetative stage highest dry matter production 15.25 g pot^{-1} was recorded in the treatment T_{11} followed by T_7 14.44 g pot^{-1} and lowest dry matter production 5.17 g pot^{-1} was recorded with application of RDF alone. At panicle initiation stage highest dry matter production 18.16 g pot^{-1} was recorded in the treatment T_{11} followed by T_9 16.62 g pot^{-1} which was on par with T_7 16.11 g pot^{-1} and in turn it was on par with T_{10} 15.44 g pot^{-1} and lowest dry matter production 6.33 g pot^{-1} was recorded with application of RDF alone.

Similarly at harvest highest dry matter production 21.42 g pot^{-1} was recorded in the treatment T_{11} followed by T_9 19.20 g pot^{-1} which was on par with T_7 19.11 g pot^{-1} and in turn it was on par with T_{10} 18.01 g pot^{-1} and lowest dry matter production was recorded with application of RDF alone 7.23 g pot^{-1}. The above results indicated that the dry matter production of rice increased with the application of $FeSO_4$ than that of Fe-complexes. This could be due to the increased solubility of Fe from $FeSO_4$ than from Fe-complexes and made available to crop plants at faster rate (Srilatha, 2001) [15]. Humic substances (humic acid and fulvic acid) with its auxin activity induce hormonal effect on catalytic activity cell permeability and increases nutrient uptake and dry matter yield (Thakur *et al.*, 2013) [17].

Table 1: Uptake of N, P, K (g pot^{-1}) and Fe (µg pot^{-1}) at different stages of rice as influenced by different treatments.

Treatments	Nitrogen (g pot^{-1})			Phosphorus (g pot^{-1})			Potassium (g pot^{-1})			Iron (µg pot^{-1})			Dry matter (g pot^{-1})		
	Crop Stages			Crop Stages			Crop Stages			Crop Stages			Crop Stages		
	Veg	PI	Harv	Veg	PI	Harv	Veg	PI	Harv	Veg	PI	Harv	Veg	PI	Harv
T_1	2.83	4.48	7.59	0.53	0.80	1.16	3.71	5.06	9.17	5.20	9.09	24.73	5.17	6.33	7.23
T_2	6.68	8.48	15.73	1.24	1.55	2.13	7.01	10.02	21.11	16.73	25.88	66.93	8.65	10.58	11.61
T_3	5.84	7.48	13.52	1.01	1.29	1.81	6.16	8.48	18.43	13.62	19.75	54.17	7.76	9.43	10.45
T_4	7.62	8.80	18.24	1.42	1.76	2.37	7.88	10.83	23.21	20.78	28.28	78.48	9.45	10.79	12.45
T_5	13.13	15.73	30.93	2.22	2.86	3.60	11.13	15.33	33.14	36.63	49.02	118.59	12.33	14.32	16.32
T_6	10.34	10.33	23.25	1.94	2.03	2.78	9.89	11.83	27.77	29.70	35.41	98.23	11.40	11.48	14.14
T_7	18.63	20.76	40.41	2.74	3.49	4.65	14.47	17.66	40.12	49.31	64.04	145.14	14.44	16.11	19.11
T_8	12.09	19.37	27.86	1.66	2.54	2.62	9.88	14.02	24.77	26.19	38.84	105.04	11.86	14.35	16.18
T_9	18.52	26.16	43.36	2.68	3.66	4.37	12.01	17.50	38.66	43.05	62.63	151.92	13.36	16.62	19.20
T_{101}	16.54	21.74	32.81	2.27	3.14	3.38	10.74	15.49	29.25	31.78	47.16	128.22	12.40	15.44	18.01
T_{11}	24.11	31.34	51.96	3.26	4.31	5.64	15.72	20.49	47.81	54.68	80.23	187.70	15.25	18.16	21.42
S. E m. ±	0.34	0.42	0.80	0.05	0.06	0.09	0.27	0.36	0.82	0.79	1.14	2.83	0.29	0.35	0.42
C.D. (0.05)	1.02	1.24	2.36	0.15	0.20	0.26	0.82	1.07	2.43	2.35	3.38	8.35	0.85	1.03	1.25

T_1-Control, T_2-Fulvic acid, T_3-Humic acid, T_4- Soil application of Fe-chelate @ 2.5 mg Fe kg^{-1} soil, T_5- Soil application of Fe-fulvate @ 2.5 mg Fe kg^{-1} soil, T_6- Soil application of Fe-humate @ 2.5 mg Fe kg^{-1} soil, T_7- Soil application of $FeSO_4$ @ 2.5 mg Fe kg^{-1} soil, T_8- Foliar application of Fe-chelate @ 0.25% at vegetative stage and panicle initiation stage, T_9- Foliar application of Fe-fulvate @ 0.25% at vegetative stage and panicle initiation stage, T_{10}- Foliar application of Fe-humate @ 0.25% at vegetative stage and panicle initiation stage, T_{11}- Foliar application of $FeSO_4$ @0.25% at vegetative stage and panicle initiation stage.

Veg-Vegetative stage, PI-Panicle Initiation stage, Harv-Harvest stage.

Conclusions

The above results indicated that among all the treatments imposed $FeSO_4$ showed higher nutrient N, P and K uptake by rice. This could be due to the increased solubility of Fe from $FeSO_4$ than that from Fe-complexes and higher availability to crop plants. Among humic substances, fulvic acid showed higher nutrient uptake over humic acid and this could be due to the formation of more soluble fulvic - metal complexes as fulvic acid is more soluble in water, whereas humic acid tend to produce more insoluble metal complexes. Humic substances (humic acid) attracts positive ions, forms chelates with micronutrients and releases them slowly when required by plants and act as chelating agents there by prevents formation of precipitation, fixation, leaching and oxidation of micronutrients in soil. Humic substances (humic acid and fulvic acid) with its auxin activity induce hormonal effect on catalytic activity cell permeability and increases nutrient uptake and dry matter yield.

References

1. Ahmed AHH, Darwish E, Hamoda SAF, Alobaidy MG. Effect of putrescine and humic acid on growth, yield and chemical composition of cotton plants grown under saline soil conditions. American-Eurasian Journal of Agriculture Environmental Science. 2013; 13:479-497.
2. Barbosa FMP, Yamasa T. Upland rice production in Brazil. Better Crop International. 2002; 16:43-46.
3. Bouman BAM, Henogsdijk H, Hardy B, Bindraban PS, Tvone TP, Ladha JK. Foreword, Proc. of the International Workshop on water wise rice production. International Rice Research Institute, Manila, Philippines, 2002.
4. El-Razek EA, Abd-Allah ASE, Saleh MMS. Yield and fruit quality of Florida Prince peach trees as affected by foliar and soil applications of humic acid. Journal of Applied Science Research. 2012; 8(12):5724-5729.

5. Fong SS, Seng L, Mat HB. Reuse of nitric acid in the oxidative pretreatment step for preparation of humic acids from low rank coal of mukash, Sarawak. Journal of Brazil Chemistry Society. 2007; 18:41-46.
6. Gondar D, Lopez FS, Antelo JM, Arce F. Cadmium, lead, and copper binding to humic acid and fulvic acid extracted from an ombrotrophic peat bog. *Geoderma.* 2006; 13:196-203.
7. Graham RD, Stangoulis JCR. Trace element uptake and distribution in plants. Journal of Nutrition. 2003; 133:1502-1505.
8. Guminski S. Present day views on physiological effects induced in plant organisms by humic compounds. Soviet Soil Science. 1968; 9:1250-1256.
9. Ihsanullah D, Bakhashwain AA. Effect of humic acid on growth and quality of maize fodder production. Pakistan Journal of Botany. 2013; 45:21-25.
10. Jackson ML. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi, 1973; 38-56.
11. Kadam SR, Amrutsagar VM, Deshpande AN. Influence of organic nitrogen sources with fulvic acid spray on yield and nutrient uptake of soyabean on inceptisol. Journal of Soils and Crops. 2010; 20(1):58-63.
12. Lindsay WC, Norvell A. Development of DTPA soil test for zinc, iron, manganese and copper. Soil Science Society of America Journal. 1978; 42:421-428.
13. Piper CS. Soil and Plant Analysis. Hans Publishers, Bombay, 1966, 137-153.
14. Sathiyabama K. Foliar application of humic acid for rice yield and nutrition. Journal of Ecobiology. 2009; 25(3):241-244.
15. Srilatha M. Characterization of humic substances and their interactions with metal ions in relation to their availability to rice. *M.Sc. Ag. thesis* submitted to Acharya N.G. Ranga Agricultural University, Rajendranagar and Hyderabad, 2001.
16. Terry N. Physiology of trace element toxicity and its relation to iron stress. Journal of Plant Nutrition, 1981; 3(1-4):561–578.
17. Thakur H, Bhanu Rekha K, Babu SNS, Padmaja G. Effect of humic substances on growth and yield of sunflower *Helianthus annuus* L.. Journal of Research ANGRAU, 2013; 41(4):106-108.
18. Tuong TP, Bouman BAM. Rice production in water-scarce environments. In Water productivity in Agriculture: Limits and opportunities for improvement, ed. J. W. Kijine, R. Baker, and D. Molden, Wallingford, UK: CAB International, 2003, 53-67.
19. Vaughan D, Linehan DJ. The growth of wheat plants in humic acid solutions under axenic conditions. Plant and Soil, 1976, 44:445-499.
20. Wang HQ, Bouman BAM, Zhao DL, Wang C, Moya PF. Aerobic rice in northern China: Opportunities and challenges. In: Bouman BAM, Henogsdijk H, Hardy B, Bindraban PS, Tuong TP, Ladha JK. Eds, Water-wise rice production. Proceedings of the International Workshop on Water-wise Rice Production, 8-11 April 2002, Los Baños, Philippines. Los Baños Phlippines: International Rice Research Institute, 2002, 143-154.