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Soil Application of Different Nutrient Levels with Soil Amendment Charred Rice Husk and Seed Treatment of *Arbuscular mycorrhizae*: Effects on Crop Productivity and Nutrient Uptake on Groundnut (*Arachis hypogaea* L.)

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ABSTRACT

Background: Different levels of nutrient management practice and soil amendments charred rice husk with *Arbuscular mycorrhizae* during the critical stages of the crop growth enhances the productivity of the groundnut crop.

Methods: The field experiments were conducted summer, *kharif* and *rabi* seasons of 2016-17 and 2017-2018 at AC and RI, TNAU, Madurai. The main plots consisted of three levels of irrigation scheduling *viz.,* I_1- 0.8 IW/CPE, I_2- 0.6 IW/CPE and I_3- 0.6 IW/CPE ratio and sub plot comprised of four level of nutrient management practices *viz.,* N_1-75% of recommended dose of fertilizer with 5t of charred rice husk, N_2- 50% of recommended dose of fertilizer with 5t of charred rice husk, N_3-75% of recommended dose of fertilizer with 5t of charred rice husk along with seed treatment of *Arbuscular mycorrhiza* and N_4- 50% of recommended dose of fertilizer with 5t of charred rice husk along with seed treatment *Arbuscular mycorrhiza*.

Result: The study revealed that the highest plant height, dry matter production, leaf area index, leaf single photon avalanche diode value, pod yield and haulm yield, nutrient uptake (N,P,K) of groundnut crop and soil enzyme activities in soil was registered with the application of 75% recommended dose of fertilizer and 5t of charred rice husk as basal with seed treatment of *Arbuscular mycorrhiza.* The highest pod and haulm yield of 1783, 1935 and 1854 kg ha^{-1} and 4743, 4272 and 4338 kg ha^{-1} during summer, *kharif* and *rabi*' 2017 seasons respectively of groundnut was registered with 75% of recommended dose of fertilizer and 5t of charred rice husk as basal with seed treatment of *Arbuscular mycorrhiza.*

Key words: Groundnut, Growth, Nutrient uptake, Soil enzyme activity, Yield.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.), belongs to the legume family (*Fabaceae*). Peanuts are often referred as poor man's protein. They are widely cultivated in India, Africa, USA, China and other countries. India occupies the first position in terms of area and second position in terms of production with a cultivated area of 5.34 million hectares and production of 7.46 million tons with average productivity of 1398 kg ha^{-1} (DES, 2018-19) Availability of nutrients is the main factor which determines the productivity of the groundnut, especially during the critical stage (Balasubramanian *et al.,* 2020).

The annual rice husk available in India is around 24 million tons (Shwetha *et al*., 2014). Charred rice husk is a unique adsorbent material with 20 to 30% pore space. Normally *arbuscular mycorrhiza* is a mutualistic relationship between host plants and can provide nutrients to the host plant in exchange for carbohydrates provided by the host plant for the fungi and seeds inoculated with *arbuscular mycorrhiza* are generally more efficient in the utilization of nutrients and lead to improved plant growth (Osseni *et al*., 2010). The present study was carried out on the influence of different levels of nutrient management practices with soil amendment of charred rice husk along seed treatment of

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arbuscular mycorrhiza on productivity and nutrients use on groundnut crop during summer, *kharif* and *rabi* seasons respectively.

MATERIALS AND METHODS

Field experiments were conducted summer, *kharif* and *rabi* seasons of 2016-17 and 2017-2018 at AC and RI, TNAU, Madurai. The experimental field was sandy loam in texture and belongs to vylogam series. The structural morphology of charred rice husk was studied by using a scanning electron microscope at low and high resolutions and diameter varied from 3-4 µm. The soil was low in available nitrogen (151.50, 158.75 and 156.00 kg ha^{-1}), medium in available phosphorus (21.20, 24.00 and 23.00 kg ha^{-1}) and high in available potassium (191.50, 199.50 and 197.00 kg ha^{-1}). The experiment was laid out in a split plot design with three replications. The main plots consisted of three levels of irrigation scheduling *viz.,* I_1- 0.8 IW/CPE, I_2- 0.6 IW/CPE and I_3- 0.6 IW/CPE ratio and sub plot comprised of four level of nutrient management practices *viz.,* N_1- 75% of recommended dose of fertilizer with 5t of charred rice husk, N_2- 50% of recommended dose of fertilizer with 5t of charred rice husk, N_3- 75% of recommended dose of fertilizer with 5t of charred rice husk along with seed treatment of *Arbuscular mycorrhiza* and N_4- 50% of recommended dose of fertilizer with 5t of charred rice husk along with seed treatment *arbuscular mycorrhiza*. The bunch variety VRI-2 (100-110 days) with a seed rate of 125 kg kernel ha^{-1} was used. The seeds were treated with *arbuscular mycorrhiza* culture at 10 g ha^{-1} of seeds. Spacing of 30 cm between rows and 10 cm between plants was adopted. Soil amendment *i.e.,* charred rice husk was applied at 5t (moisture-free) and incorporated well in the field before sowing of crop. The entire quantity of nutrients (N,P,K) *i.e.,* 25:50:75 kg ha^{-1} was applied as basal before sowing and no top dressing was done. Growth parameters, plant height, leaf area index dry matter production, pod and haulm yield and nutrient uptake were recorded and the experimental data collected were statistical analysis by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Growth attributes

Plant height and dry matter production of groundnut were influenced by different levels of nutrient management practices (Table 1 and 2). The tallest plant heights of 48.25, 49.26 and 46.32 cm and dry matter production of 4998, 5030 and 4805 kg ha^{-1} were observed with 75% of recommended dose of fertilizer adding with 5t of charred rice husk along with seed treatment of *arbuscular mycorrhiza* at harvest stage during summer, *kharif* and *rabi* seasons respectively. Application of nutrients along with soil amendment of charred rice husk which has supplied adequate moisture might have increased the microbial activity, presence of adequate carbon in the soil and provide a good microclimatic environment in the rhizosphere region of the crop (Balasubramanian *et al.,* 2020). Further, conjugation of *arbuscular mycorrhiza* could have paved way for increased availability of nutrients resulting in enhanced root growth. It also creates a more adsorptive surface for the uptake of nutrients by the crop. The earlier works of Hogan (2011) and Zhang *et al*. (2014) corroborates the above findings.

Physiological parameters

Physiological parameters were significantly influenced by the application of 75% of recommended dose of fertilizer conjugated with 5t of charred rice husk along with seed treatment with *arbuscular mycorrhiza* (Table 3). Higher leaf

Table 1: Effect of nutrient management practices on plant height (cm) of groundnut at harvest.

Treatment	Summer				*Kharif*				*Rabi*			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
N_1	47.89	46.56	42.46	45.60	48.58	47.60	40.53	45.57	44.74	43.70	37.83	42.12
N_2	47.70	45.22	42.13	45.07	41.52	40.28	39.80	40.53	44.65	41.81	36.42	40.91
N_3	50.06	49.46	45.22	48.25	52.79	51.43	43.57	49.26	51.21	46.05	42.61	46.32
N_4	48.91	47.89	45.78	47.53	47.90	48.15	42.50	46.18	47.62	47.86	39.43	44.80
SEd	0.55	0.77	1.09	1.09	0.78	0.70	0.99	0.99	0.81	0.72	1.02	1.02
CD (p=0.05)	1.30	1.64	2.12	2.12	1.84	1.50	1.93	1.93	1.90	1.54	1.99	1.99

Table 2: Effect of nutrient management practices on dry matter production (kg ha^{-1}) of groundnut at harvest.

Treatment	Summer				*Kharif*				*Rabi*			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
N_1	4966	4654	3984	4534	4962	4663	4250	4625	4750	4554	4119	4474
N_2	4978	4735	3926	4546	4904	4530	4153	4529	4588	4389	4005	4327
N_3	5323	5276	4397	4998	5328	5275	4486	5030	5076	4981	4359	4805
N_4	5145	5036	4371	4850	5120	5068	4428	4872	4992	4728	4295	4672
SEd	47	56	80	80	106	94	133	133	88	86	122	122
CD (p=0.05)	110	119	153	153	250	201	259	259	208	184	237	237

area index with respect value of 3.89, 3.93 and 3.86 at harvest stage and leaf single photon avalanche diode (Table 4) with a value of 54.25, 55.34 and at 75DAS during summer, *kharif* and *rabi* seasons respectively. It might be due to higher chlorophyll content by application of sufficient amount of nutrients along with charred rice husk, leading to the higher photosynthetic efficiency by higher uptake and utilization of nutrients by the crop. This corroborates with the findings of Panwar (1991).

Yield

Concerning nutrient management practices, application of 75% of recommended dose of fertilizer in combination with 5t of charred rice husk along with seed treatment of *arbuscular mycorrhiza* recorded the higher pod yield (1783, 1935 and 1854 kg ha^{-1}) and haulm yield (4401, 4272 and 4950 kg ha^{-1} during summer, *kharif* and *rabi*) and the data are furnished in Table 5a, 5b and 5c. The presence of growth-promoting substances due to the colonization of *arbuscular mycorrhiza* promoted plant growth and could have increased chlorophyll production by boosting the photosynthetic process and stimulating vegetative growth. Thus, an overall plant performance would have enhanced accordingly and finally reflecting through increased production of haulm (Gouda *et al.,* 2018). Moreover, basal application of soil amendment of charred rice husk along with seed treatment of *Arbuscular mycorrhiza* might have had a positive effect on the soil physical properties such as bulk density and pore space, which could have increased the water retention capacity. Enriched charred rice husk 1983 and haulm 5115 kg/ha. With respect to economics, among the organic manure treatments, the charred rice husk recorded the gross return of Rs. 60300/ha, maximum net return of Rs.37457/ha and benefit cost ratio of 2.64 due to the cheaper material cost (Balasubramanian and Chinnamuthu, 2021).

Nutrient uptake

The uptake of nutrients (N,P,K) in 75% of recommended dose of fertilizer with 5t of charred rice husk and seed treatment with *arbuscular mycorrhiza* recorded the highest nitrogen, phosphorus and potassium uptake with the value of 106.02, 32.43 and 66.20 kg ha^{-1} during summer, 106.37, 65.03 and 122.31 kg ha^{-1} during *kharif* and 106.56, 30.03 and 59.14 kg ha^{-1} during *rabi* seasons at 75 DAS and the

Table 3: Effect of nutrient management practices on leaf area index of groundnut at harvest.

Treatment	Summer				*Kharif*				*Rabi*			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
N_1	3.79	3.84	3.31	3.65	3.79	3.74	3.49	3.67	3.71	3.66	3.33	3.57
N_2	3.67	3.60	3.28	3.52	3.64	3.58	3.41	3.54	3.62	3.55	3.21	3.46
N_3	4.12	4.03	3.52	3.89	4.13	4.01	3.65	3.93	4.10	4.02	3.53	3.86
N_4	3.99	3.73	3.46	3.73	3.95	3.90	3.56	3.80	3.92	3.84	3.46	3.74
SEd	0.12	0.16	0.22	0.22	0.10	0.12	0.16	0.16	0.04	0.12	0.17	0.17
CD (p=0.05)	0.29	0.34	NS	NS	0.23	0.25	NS	NS	0.10	0.26	NS	NS

Table 4: Effect of nutrient management practices on leaf single photon avalanche diode value of groundnut at 75 DAS.

Treatment	Summer				*Kharif*				*Rabi*			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
N_1	53.09	51.94	44.00	49.68	54.95	52.91	45.47	51.15	51.85	48.34	42.77	47.65
N_2	52.67	50.33	43.95	48.98	53.19	50.15	44.88	49.37	49.71	46.21	40.08	45.33
N_3	56.67	59.07	47.01	54.25	59.64	57.50	48.97	55.34	55.93	53.82	45.97	51.91
N_4	55.82	56.67	45.87	52.79	56.92	56.34	47.40	53.52	53.40	51.00	44.21	49.54
SEd	0.60	2.00	2.82	2.82	1.59	1.97	2.79	2.79	1.06	0.10	1.41	1.41
CD (p=0.05)	1.40	4.25	NS	NS	3.73	4.21	2.23	2.23	2.49	2.13	2.74	2.74

Table 5a: Effect of nutrient management practices on pod yield, haulm yield of groundnut during *summer'* 2017.

Treatment	Pod yield (kg ha^{-1})				Haulm yield (kg ha^{-1})			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
N_1	1830	1693	1275	1599	4726	4616	4155	4499
N_2	1726	1646	1236	1536	4715	4538	4023	4425
N_3	2003	1978	1365	1783	4984	4846	4401	4743
N_4	1918	1886	1433	1745	4888	4809	4330	4675
SEd	50	51	72	72	76	58	82	82
CD (p=0.05)	117	108	140	140	180	124	160	160

data are furnished in Table 6, 7 and 8. Normally, charred rice husk being highly porous with the high specific surface area was attributed to the release of more nutrients in to soil and act as mulching on soil microflora. This could be explained due to the regulation of soil temperature, conservation of moisture and improvement in the humic acid content of the soil that are important factors in increasing the zymogenic soil microflora. In legume plants, the importance of *arbuscular mycorrhiza* symbiosis has been attributed to high phosphorus requirements on the nodulation and nitrogen fixation process. In this present study, seed treatment with *Arbuscular mycorrhiza* enhanced the growth of plants and also enhanced the uptake of phosphorus. Further, *Arbuscular mycorrhiza* has

Table 5b: Effect of nutrient management practices on pod yield, haulm yield of groundnut during *kharif*' 2017.

Treatment	Pod yield (kg ha^{-1})				Haulm yield (kg ha^{-1})			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
N_1	1978	1845	1329	1717	4760	4471	3897	4376
N_2	1871	1766	1288	1641	4606	4384	3768	4253
N_3	2099	2022	1685	1935	5062	5004	4272	4779
N_4	2075	2004	1623	1901	4936	4863	4215	4671
SEd	32	44	63	63	72	81	114	114
CD (p=0.05)	75	95	122	122	170	172	222	222

Table 5c: Effect of nutrient management practices on pod yield, haulm yield of groundnut during *rabi*' 2017.

Treatment	Pod yield (kg ha^{-1})				Haulm yield (kg ha^{-1})			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
N_1	1810	1662	1251	1574	4658	4208	4132	4333
N_2	1749	1644	1266	1553	4548	4489	4016	4351
N_3	2063	2001	1498	1854	5083	4950	4338	4790
N_4	1937	1857	1415	1736	4950	4770	4128	4616
SEd	40	47	66	66	101	87	123	123
CD (p=0.05)	94	99	128	128	2386	186	239	239

Table 6: Effect of nutrient management practices on nitrogen uptake (kg ha^{-1}) of groundnut at 75 DAS.

Treatment	Summer				*Kharif*				*Rabi*			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
N_1	102.57	99.81	96.41	98.11	103.93	101.81	83.43	96.42	104.74	99.90	87.83	97.49
N_2	98.70	96.58	93.67	96.32	101.34	98.83	81.25	93.84	101.60	97.20	86.87	95.22
N_3	111.02	107.80	99.25	106.02	113.26	111.05	94.69	106.37	113.56	111.89	94.23	106.56
N_4	105.68	103.54	97.29	102.17	109.81	103.79	90.22	101.34	109.07	103.58	92.71	101.79
SEd	0.86	1.10	1.55	1.552	2.40	1.93	2.74	2.74	1.69	1.79	2.53	2.53
CD (p=0.05)	2.01	2.34	3.02	3.02	5.64	4.12	5.31	5.31	3.98	3.81	4.91	4.91

Table 7: Effect of nutrient management practices on phosphorus uptake (kg ha^{-1}) of groundnut at 75 DAS.

Treatment	Summer				*Kharif*				*Rabi*			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
N_1	31.51	30.14	25.77	29.14	29.09	27.06	21.62	25.96	28.97	26.62	20.73	25.43
N_2	30.08	28.24	24.49	27.60	28.10	25.91	20.16	24.82	26.52	24.48	18.46	23.14
N_3	36.31	33.11	27.87	32.43	34.55	32.53	24.91	30.63	33.08	32.33	24.61	30.03
N_4	34.13	31.27	26.82	30.74	32.63	31.25	25.39	29.95	31.57	30.47	23.33	28.55
SEd	0.72	0.75	1.07	1.07	0.79	1.02	1.44	1.44	0.75	0.91	1.29	1.29
CD (p=0.05)	1.69	1.61	2.07	2.07	1.86	2.18	2.81	2.81	1.77	1.95	2.51	2.51

Table 8: Effect of nutrient management practices on potassium uptake (kg ha^{-1}) of groundnut at 75 DAS.

Treatment	Summer				*Kharif*				*Rabi*			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
N_1	64.28	61.89	54.21	60.13	64.22	62.31	52.80	59.71	61.04	54.58	46.03	53.88
N_2	62.04	60.33	53.64	58.67	62.84	60.42	50.37	57.84	54.87	50.43	45.58	50.29
N_3	70.18	69.51	58.92	66.20	68.33	67.24	59.64	65.03	64.26	61.99	51.17	59.14
N_4	67.28	68.15	57.24	64.22	66.17	65.61	58.53	63.43	60.23	59.52	49.58	56.44
SEd	0.92	1.32	1.86	1.86	1.01	1.14	1.61	1.61	1.12	1.74	2.47	2.47
CD (p=0.05)	2.16	2.81	3.62	3.62	2.37	2.43	3.13	3.13	2.63	3.72	4.79	4.79

Table 9: Effect of nutrient management practices on arylsulphatase enzyme activities of groundnut at 75 DAS.

Treatment	Summer				*Kharif*				*Rabi*			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
N_1	77±3.4	72±2.2	61±1.0	70	72±1.7	69±2.6	59±1.7	66	75±3.4	72±2.2	63±1.0	67
N_2	73±1.1	70±1.5	58±1.3	67	70±2.4	70±2.5	55±2.8	63	72±2.0	60±2.2	60±1.3	64
N_3	83±3.1	80±2.7	70±1.7	78	74±3.1	75±3.3	68±2.4	72	81±2.7	77±3.1	70±1.7	76
N_4	80±2.9	80±2.5	70±1.7	77	73±3.3	73±1.7	66±1.5	71	77±2.9	75±2.5	68±1.7	73
SEd	2	2	3	3	1	1	2	2	2	2	2	2
CD (p=0.05)	6	4	5	5	3	3	3	3	4	4	5	5

Table 10: Effect of nutrient management practices on phosphatase enzyme activity of groundnut at 75 DAS.

Treatment	Summer				*Kharif*				*Rabi*			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
N_1	81±2.5	78±3.0	69±2.0	76	93±2.3	89±2.4	75±2.8	86	83±2.5	74±3.0	70±2.0	76
N_2	78±2.6	73±2.2	65±2.4	72	92±2.1	84±1.9	74±2.2	82	75±2.6	70±2.2	64±2.4	70
N_3	98±2.6	95±2.6	72±2.3	88	88±3.1	101±2.2	74±1.6	92	100±2.6	95±2.6	86±2.3	94
N_4	94±3.1	91±2.9	71±2.2	85	96±2.7	98±2.4	82±3.1	90	96±3.1	92±2.9	82±2.2	90
SEd	3	4	5	5	2	2	3	3	1	3	4	4
CD (p=0.05)	6	8	10	10	5	5	6	6	2	7	9	9

Table 11: Effect of nutrient management practices on dehydrogenase enzyme activity of groundnut at 75 DAS.

Treatment	Summer				*Kharif*				*Rabi*			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
N_1	80±2.9	76±2.6	62±1.7	72	76±2.3	75±2.4	64±2.8	72	75±2.9	71±2.6	64±1.7	70
N_2	77±2.8	70±2.3	58±2.3	68	74±2.1	71±1.9	60±2.2	68	70±2.8	66±2.3	59±2.3	65
N_3	91±3.1	88±2.7	74±1.9	84	78±3.1	81±2.2	75±1.6	78	87±3.1	81±2.7	74±1.9	81
N_4	87±2.7	85±2.7	71±2.6	80	81±2.7	76±2.4	73±3.1	76	80±2.7	86±2.7	71±2.6	79
SEd	2	2	3	3	1	2	3	3	2	3	5	5
CD (p=0.05)	5	5	6	6	3	4	6	6	4	7	9	9

a specialized intracellular structure and highly ramified hyphae with very fine terminal tips, resulting in a surface to volume ratio that is greater and the cells that are inhabited by *arbuscular* develop elaborate machinery for active nutrient transfer (Steiner *et al*., 2011).

Soil enzyme activity

The experimental data revealed that the activity of the arylsulphatase, phosphatase and dehydrogenase enzyme were largely varied by different levels of nutrient management practices and the data are furnished in Table 9, 10 and 11. Application of 75% of recommended dose of fertilizer with 5t charred rice husk and seed treatment with *Arbuscular mycorrhiza* recorded higher arylsulphatase, phosphatase and dehydrogenase enzyme activity of 78,88 and 84 µg g^{-1} h^{-1} during summer 72, 92 and 78 µg g^{-1} h^{-1} during *kharif*' 76, 94 and 81 µg g^{-1} h^{-1} during *rabi* at 75DAS in the soil. The addition of soil amendment as rice husk served as a carbon source which enhanced the microbial biomass in the soil with the advancement of crop growth stages (Yao *et al*., 2006). Cohn *et al*. (1998)

reported that an adequate supply of nutrients could enhance the nitrogen transforming microorganisms which could have increased the nutrient availability in the soil. Thus, it could have resulted in increased uptake of nutrients resulting in higher yield.

CONCLUSION

From the present investigation, it can be concluded that application of 75% recommended dose of fertilizer and 5 t of charred rice husk as basal with seed treatment of arbuscular mycorrhiza. The highest pod and haulm yield of 1783, 1935 and 1854 kg ha^{-1} and 4743, 4272 and 4338 kg ha^{-1} during summer, *kharif* and *rabi*' 2017 seasons respectively. Application of 75% of recommended dose of fertilizer and 5 t of charred rice husk as basal with seed treatment of arbuscular mycorrhiza would be an ideal practice for improving nutrient use efficiency, getting higher yield and economic returns.

Conflict of interest

All authors declared that there is no conflict of interest.

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