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Research Paper

Influence of Residual Effect of Fly Ash, Organics, and Fertilizers on Growth Characters and Yield of Green Gram in Rice-Rice-Green Gram Sequence

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A B S T R A C T

Field experiments were carried out in season 2018 and 2019 to study the influence residual effect of incorporation lignite fly ash, organics and fertilizers alone or in combination on some yield characters viz. plant height, number of pod plant^{-1}, number of cluster plant^{-1}, number of pod plant^{-1}, number of seed pod^{-1}, test weight, yield and nutrient uptake of green gram (*Vigna radiata* L.) in clay loam soil-based cropping system. The experiments were laid out in randomized block dosing with two factors; factor A): 0 and 10 t lignite fly ash ha^{-1} and factor B): ten different nutrient management treatments, replicated trice. The results revealed that the residual effect of the integrated use of lignite fly ash, organics and fertilizers had significantly more effective than no fly ash. The Interaction effect between lignite fly ash with different organics and fertilizer on plant height, cluster plant^{-1}, and seed pod^{-1} was not significant but was significant on pod plant^{-1}, test seed weight, haulm and seed yield as well as NPK uptake in both years 2018 and 2019. The maximum haulm and seed yield were recorded with the residual effect of 100% NPK + 10 t LFA ha^{-1} + 10 t SPM ha^{-1} of 2751 and 2833 kg ha^{-1} of haulm yield and 422 and 430 kg ha^{-1} of seed yield, in 2018 and 2019 respectively. The greatest NPK uptake by haulm and the seed was noticed also with 100% NPK + 10 t LFA ha^{-1} + 10 t SPM ha^{-1} followed by the residual effect of integrated 100% NPK + 10 t LFA ha^{-1} + 10 t FYM ha^{-1}. The lowest value of yield characters and yield was registered in the control treatment.

***Key words*:** *Vigna radiata*, Cropping system, Lignite fly ash, Green gram, Organics, Residual effect

Green gram (*Vigna radiata* L.) is one of the major pulse crops in India, it spread on an area of 4.1 M ha with total production about 1.9 M t [1] and with consumption was estimated with 22 Mt [2]. Green gram is one of the crops which rich in protein wherein consists of 24-26% protein also with a number of nutritious elements like P, K, Ca, and Na also in A, B, B_3 vitamins [3]. In addition to its nutritional importance, it also plays a vital role to improve soil nitrogen through the biological fixation of nitrogen. Soil health and productivity decline, one of the essential problems that hinder agricultural producers. Improper nutrient management is one of the essential factors for the decline of productivity of crops. neither chemical fertilizer alone nor organic manures application can sustain soil health and crop productivity, also using sole chemical fertilizer for a long time without any additions of any organic material could lead to adverse effects to soil physico-chemical and biological properties, but the incorporation of organic materials and inorganic fertilizers could have a greater effect on soil and yield as direct and/or as a residual effect, also lead to reducing chemical fertilizer cost due to present a considerable concentration of nutrition plant element in it. Farmyard manure, vermicompost, green manure, sugar press mud, are wildly is being used by farmers which were evidence of its affective to improve soil health, productivity, and quality of yield when it combined with chemical fertilizers and is treated with proper ways. Integrated use of vermicompost along with chemical fertilizer (N, P, and K) significantly increased pod plant^{-1}, test weight of seeds, seed, and haulm yield over sole chemical fertilizer application in green gram under sandy loam soil [4]. The integrated use of 5 t farmyard manure ha^{-1} produced the highest grain yield and protein content. The residual effect of combined application of chemical fertilizers along with 10 t FYM ha^{-1} recorded significantly higher yield attribute and yield of succeeding green gram crop in maize – green gram sequence among other treatments [6]. Fly ash is inorganic wastes, is produced from the thermal power stations.

India produces a large amount of fly ash, dumping up such amount amounts would lead to big environmental problems. Utilizing fly ash as a soil amendment may one of the safest ways to disposal from it, with along it is a source of a number of plant nutrient elements such as P, K, Ca, S, Cu, Zn, Fe, Si, and AL [7]. Several researches noted that application of fly ash in combination with inorganic fertilizers and/or along organic wastes improved soil health and productivity of several crops. The application of fly ash with the rate at 150 t ha^{-1} increased the yield of green gram by 20 - 25% over control in vertisol [8]. The residual effect of organic and inorganic

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fertilizers which are added to preceding crops could have a positive effect on succeeding crops. Addition of (40: 20 kg N: P_2O_5 ha^{-1}) with 10 t FYM ha^{-1} to finger millet recorded significantly influence on growth yield and yield of green gram as succeeding crop in finger millet-green gram cropping system [9]. integrated use of either 75% RDN as inorganic fertilizer + 25% RDN as bio-compost or 75% RDN as inorganic fertilizer + 25% RDN as vermicompost along with a recommended dose of 60 kg P_2O_5 ha^{-1} to maize had a significant effect on growth attributes and yield of succeeding green gram [6]. Cropping system as rice– rice–green one of the farming practices which is being followed in the Cauvery delta area. So, this study aimed to investigate the residual effect of integrated different organics manures and fertilizers with and without fly ash on rice fallow green gram in the Cauvery delta area.

MATERIALS AND METHODS

Field experiments were conducted during season 2018-2019 in farmer's holding located at Pinnalore village, Cuddalore district, Tamil Nadu, India, to investigate the residual effect of the application of lignite fly ash, organic and fertilizers on growth yield and yield of green gram (ADT 3) in rice – rice – green gram system under vertisol (clay loam in texture). The experiment was laid down in randomized block design (RBD), with two factors; factor A): 0 t ha^{-1} lignite fly ash (-LFA) and 10 t ha^{-1} (+LFA), factor B) ten fertilizer treatment viz. T_1: Absolute control, T_2: 100% Recommended does fertilizer (NPK), T_3: 50% N + 100% PK + FYM (farmyard manure), T_4: 50% N+ 100% PK+ VC (vermicompost), T_5: 50% N+ 100PK+ GM (green manure), T_6: 100% NPK + SPM (Sugar press mud), T_7: 100% NPK+ FYM, T_8: 100% NPK + VC, T_9: 100% NPK + GM, T_{10}: 100% NPK + SPM. Fly ash was added with rate of 10 t ha^{-1} and organic manures with a rate of 12.5 t FYM ha^{-1}, 5 t VC ha^{-1}, 6.25 t GM (*Sesbania rostrata*) ha^{-1} and 10 t SPM ha^{-1}. All treatments were replicated trice in kharif rice (ASD 16). Chemical fertilizer was applied with a rate at 120 N: 38 P: 38 K kg ha^{-1}, while the rabi rice crop BPT 5204 received only 150: 50: 50 kg N: P: K ha^{-1}. Chemical fertilizers were applied as urea as a source of nitrogen, single super phosphate as a source of P and muriate potash as a source of K. Green gram seed was sowing 10 days before harvest of the rabi rice in the same plots with a rate at 25 kg ha^{-1}. DAP 2% was applied to green gram crop at 40 days after seed sowing as a foliar spray to all plots except control treatment. The parameter of plant growth viz. plant height, number of cluster plant^{-1}, number of pod plant^{-1}, number of seed pod^{-1} were estimated at harvest stage, while seed yield, haulm yield and, 100 seed weight was estimated after harvesting. Haulm and seed samples subjected to crunching then were digested and analyzed for N, P, and K content using modified Kjeldahl, vanadomolybdate method and flame photometer method [10]. The data was analyzed statistically as described by [11].

RESULTS AND DISCUSSION

Yield characters and yield

The results generally showed that residual effect of combined application of different organics and chemical fertilizers along with or without lignite fly ash significantly increased growth yield parameters over control.

Plant height

The residual effect of organics and fertilizers in combination with fly ash (+LFA) recorded a significantly higher plant height of 30.0 cm (2018) and 31.9 cm (2019) over no fly ash (-LFA) of 27.3 (2018) and 29.1 cm (2019) (Table 1). The residual effect of lignite fly ash alone or in combination with organic and fertilizer as an individual factor (+LFA) showed significantly taller plant height over control and 100% NPK with LFA, the tallest plant height was noticed with 100% NPK + LFA + SPM, similarly, combined application of organics with fertilizer as individual factor recorded taller plant height over control and 100% NPK. 100% NPK + SPM registered the tallest plant height. The interaction effect between lignite fly ash with organic plus fertilizer on plant height was not significant. Application of 100% N showed higher plant height compared to 50%N.

Table 1 Effect of residual effect of lignite fly ash, organic and inorganic fertilizer on growth yield of green gram

Treatments	Plant height (cm)						No of cluster plant^{-1}						No of pod plant^{-1}					
	2018			2019			2018			2019			2018			2019		
	+LFA	-LFA	Mean	+LFA	-L FA	Mean	+L FA	- LFA	Mean	+LFA	-LFA	Mean	+LFA	-LFA	Mean	+LFA	-LFA	Mean
T_1	25.9	24.0	24.9	27.7	22.8	25.2	3.5	3.3	3.4	3.8	3.3	3.5	18.3	13.6	16.0	20.3	15.1	17.7
T_2	29.1	25.8	27.4	30.2	28.6	29.4	3.7	3.5	3.5	4.6	3.4	4.0	20.3	18.6	16.5	22.6	20.3	21.5
T_3	30.9	28.1	29.5	33.3	30.3	31.8	5.7	4.7	5.1	6.3	4.6	5.5	23.6	21.3	22.5	25.0	23.0	24.0
T_4	29.6	26.8	28.2	31.2	29.0	30.1	4.6	4.3	4.5	5.6	4.0	4.8	22.3	19.3	10.8	24.0	22.3	23.1
T_5	29.2	26.2	27.7	30.7	28.6	29.6	4.0	4.3	4.1	5.3	4.0	4.6	20.6	19.0	19.8	23.3	22.2	22.6
T_6	31.2	28.7	30.0	33.3	30.6	32.0	5.6	5.0	5.3	6.3	5.0	5.6	24.3	21.0	22.6	25.0	23.3	24.1
T_7	31.8	28.8	30.3	34.2	31.2	32.7	6.6	5.3	6.0	7.3	5.6	6.5	24.3	22.3	23.3	25.0	22.7	24.3
T_8	30.2	27.7	28.9	32.8	29.6	31.2	5.0	4.6	4.8	5.6	5.3	5.5	23.3	20.3	21.8	24.7	22.7	23.7
T_9	29.9	27.6	28.7	31.3	29.3	30.3	4.6	4.3	4.5	6.0	4.6	5.3	22.3	19.6	21.0	24.3	22.7	23.5
T_{10}	32.1	29.7	30.9	34.5	31.5	33.0	7.0	5.6	6.3	7.3	6.6	7.0	25.3	23.0	24.1	26.3	24.0	25.1
Mean	30.0	27.3		31.9	29.1		5.0	4.5		5.8	4.6		22.1	19.8		24.0	21.9	
	F	T	F×T	F	T	F×T	F	T	F×T	F	T	F×T	F	T	F×T	F	T	F×T
SE_D	0.59	1.31	1.86	0.55	1.24	1.75	0.18	0.41	0.59	0.15	0.34	0.49	0.51	1.15	1.63	0.28	0.64	0.91
CD(p=0.05)	1.19	3.57	NS	1.12	2.51	NS	0.37	0.84	NS	0.31	0.70	NS	1.04	2.34	3.31	0.58	1.13	1.85

Number of cluster plant^{-1}

The data in (Table 1) revealed that the residual effect of LFA, organics, and fertilizers in combination (+LFA) recorded significantly higher cluster plant^{-1} (5.0) in 2018 and (5.8) in 2019 over no fly ash (-LFA) of 4.5 in 2018 and 4.6 in 2019. The residual effect of lignite fly ash alone or in combination with organic and fertilizer as an individual factor (+LFA) recorded significantly higher cluster plant^{-1} over control and 100% NPK with LFA, the maximum cluster plant^{-1} was noticed with 100% NPK + LFA + SPM, similarly combined

application of organics with fertilizer as individual factor recorded higher cluster plant^{-1} over control and 100% NPK. 100% NPK + SPM registered the highest cluster plant^{-1}. The interaction effect between lignite fly ash with different organics and fertilizer on number of cluster plant^{-1} was significant in both years 2018 and 2019 plant height was not significant. Application of 100% N showed higher cluster plant^{-1} over 50% N.

Number of pod plant^{-1}

Effect of residual LFA, separately or with residual organics and fertilizers (+LFA) led to significantly increase pod plant^{-1} (22.1) in the year 2018 and (24.0) in 2019 over no fly ash (-LFA) 19.8 (2018) and 21.9 (2019), (Table 1). Residual of lignite fly ash alone or in combination with organic and fertilizer as an individual factor (+LFA) significantly increased pod plant^{-1} over control and 100% NPK with LFA. The highest pod plant^{-1} was recorded with residual combined 100% NPK + LFA + SPM. Similarly the residual of organics with fertilizer as individual factor registered higher cluster plant^{-1} over control and 100% NPK. The residual effect of 100% NPK + SPM registered the highest pod plant^{-1}. Application of 100% N showed higher pod plant^{-1} over 50% N. The interaction effect between lignite fly ash with organic plus fertilizer on plant height statistically significant in both years. Among all treatments, residual effect of integrated 100% NPK + 10 t LFA ha^{-1} + 10 t SPM ha^{-1} recorded maximum pod plant^{-1} of 25.3 and 26.3 in 2018 and 2019 respectively.

Number of seed pod^{-1}

Residual of LFA, alone or associated with residual organics and fertilizers (+LFA) caused a significant increase pod plant^{-1} of 8.2 in the year (2018) and 8.8 in (2019) over no fly ash (-LFA) of 7.1 (2018) and 7.3 (2019) (Table 2). Residual of lignite fly ash alone or in combination with organic and fertilizer as an individual factor (+LFA) significantly increased pod plant^{-1} over control and 100% NPK with LFA. The highest pod plant^{-1} was recorded with residual effect of combined 100% NPK + LFA + SPM, similarly, residual effect of organics with fertilizer as individual factor registered higher cluster plant^{-1} over control and 100% NPK. The residual effect of 100% NPK + SPM registered the highest pod plant^{-1}. Application of 100% N showed higher pod plant^{-1} over 50% N. The interaction effect between lignite fly ash with organic plus fertilizer on plant height statistically not significant in both years.

Table 2 Effect of residual effect of lignite fly ash, organic and inorganic fertilizer on growth yield of green gram

Treatments	No of seed pod^{-1}						100 seed weight g					
	2018			2019			2018			2019		
	+LFA	-LFA	Mean	+LFA	-LFA	Mean	+LFA	-LFA	Mean	+LFA	-LFA	Mean
T_1	5.3	5.0	5.1	7.0	5.4	6.2	1.73	1.56	1.65	1.75	1.52	1.63
T_2	6.3	6.3	6.3	7.3	6.4	6.8	2.00	1.83	1.91	2.07	2.07	2.06
T_3	9.3	7.3	8.3	9.3	7.3	8.3	2.47	2.03	2.25	2.45	2.45	2.48
T_4	7.6	6.6	7.1	7.7	6.7	7.1	2.33	2.17	2.24	2.32	2.32	2.33
T_5	7.0	6.3	6.6	7.7	6.6	7.1	2.20	2.17	2.18	2.25	2.23	2.24
T_6	9.6	7.6	8.6	10.3	8.3	9.3	2.53	2.23	2.38	2.56	2.46	2.51
T_7	10.0	8.3	9.1	10.3	9.3	9.8	2.57	2.43	2.50	2.60	2.50	2.55
T_8	8.6	7.3	8.0	9.0	7.0	8.0	2.42	2.43	2.42	2.43	2.40	2.41
T_9	8.0	6.6	7.3	8.7	6.7	7.6	2.38	2.47	2.42	2.40	2.36	2.38
T_{10}	10.6	9.6	10.1	10.7	10	10.3	2.60	2.50	2.55	2.63	2.59	2.61
Mean	8.2	7.1		8.8	7.3		2.32	2.18		2.39	2.28	
	F	T	F×T	F	T	F×T	F	T	F×T	F	T	F×T
SE_D	0.18	0.42	0.59	0.20	0.45	0.63	0.02	0.04	0.06	0.01	0.02	0.03
CD(p=0.05)	0.38	0.85	NS	0.40	0.91	NS	0.04	0.09	0.13	0.02	0.05	0.07

Test weight of seeds

The data in (Table 2) revealed that test weight of 100 seed of green gram significantly increased cause residual effect of LFA separately or along with organics and fertilizers residual (+LFA) test weight seed (2.32 g) in 2018 and (2.39 g) in 2019 over (-LFA) of 2.18g (2018) and 2.28g (2019). Weight of green gram seed significantly influenced due to residual effect of LFA alone or in combination with organic and fertilizer as individual factor (+LFA) over control and 100% NPK with LFA, the highest pod plant^{-1} was recorded with residual integrated 100% NPK + LFA + SPM. Similarly, the residual effect of organics with fertilizer as an individual factor (-LFA) registered greater test seed weight over control and 100% NPK. The residual effect of 100% NPK + SPM registered the highest pod plant^{-1}. Application of 100% N showed higher test seed weight over 50%N. The interaction effect between lignite fly ash with organic plus fertilizer on test seed weight statistically significant in both years. Among all treatments, the highest test seed weight of 2.60 g (2018) and 2.63g (2019) was registered with a combined use of 100% NPK+10 t LFA ha^{-1} + 10 t SPM ha^{-1} as a residual effect. [9], [12], [13] they found that residual effect of the application of organic manures and fertilizers significantly increase yield attributes and yield of pulses, this might be ascribed to the improvement of microorganisms activity which supply plant nutrients by way of atmospheric N_2 fixation, and solubilizing insoluble forms of nutrients [14] which further play an important role in organics decomposition, nutrient cycling, and chemical transformations in soil [15]. Application of organics and fertilizer improved soil physico-chemical properties through the mineralization process of organic manures and the slow release of nutrients which lead to improving the availability of soil nutrients [16]. The residual effect of SPM recorded maximum yield followed by FYM of succeeding crop that cause SPM has a greater influence on available nutrients and improve soil pH [17]. The reason of increase growth parameters due to the residual effect of combined application of fly ash and organic and fertilizers might be ascribed to contribute organics and fly ash simultaneously to improve soil physico-chemical properties and soil nutrients status [18].

Haulm and seed yield

Application of fly ash organics and fertilizers individually or in combination which applied to preceding rice crop significantly increased seed yield as well as haulm yield when considering as individual factors (+LFA) and (-LFA) (Fig 1-2). The residual effect of fly ash alone or with organics and fertilizers (+LFA) achieved a significantly higher seed yield of 284 kg ha^{-1} in 2018 and 303 kg ha^{-1} in 2019 over no lignite fly ash (-LFA) of 232 kg ha^{-1} in 2018 and 249 kg ha^{-1} in 2019. The percent increase due to the residual effect of fly ash (+LFA) over (-LFA) was 20.5 (2018) and 21.1 (2019). The residual effect of combined application of 100% N showed higher green gram yield compared to 50% N. Interaction effect between lignite fly ash with different organics and fertilizer on seed yield was significant in both years 2018 and 2019. The maximum seed yield was achieved with residual effect of integrated use of 100% NPK + 10 t LFA ha^{-1} + 10 t SPM ha^{-1} (422 kg ha^{-1}) in 2018 and (430 kg ha^{-1}) in 2019 which recorded about 310 and 343% increase over the plots that did not receive any amendment (control) and 159 and 139% over 100% NPK in 2018 and 2019. Similarly, haulm yield showed significantly higher with + LFA (1837 kg ha^{-1}) in the year 2018 and (1940 kg ha^{-1}) in 2019 over -LFA (1516 kg ha^{-1}) in 2018 and (1525 kg ha^{-1}) in 2019. The interaction effect between lignite fly ash with different organics and fertilizer on haulm yield was significant in both years 2018 and 2019. The greatest haulm yield of green gram of 2751 and 2833 kg ha^{-1} in 2018 and 2019 respectively were recorded with 100% NPK + 10 t LFA ha^{-1} + 10 t SPM ha^{-1}, followed by (T_7) 100% NPK + 10 t LFA ha^{-1} + 10 t SPM ha^{-1} which caused an increase of about 337 and 425% over absolute control and 158 and 156% over 100% NPK alone. At all fertilizer treatments, green gram yield was higher with 100% N compared to 50% N. Similarly, it was higher in the presence of LFA over its absence. Application of organics along with fertilizers to preceding rice significantly affected green gram yield under rice- green gram system. The increase in green gram yield due to residual effect of fly ash alone or in combination with organics may ascribe to the slow release of nutrients from organics and fly ash together through the biochemical process which improved growth yield parameters which had directly reflected on seed and haulm yield [19].

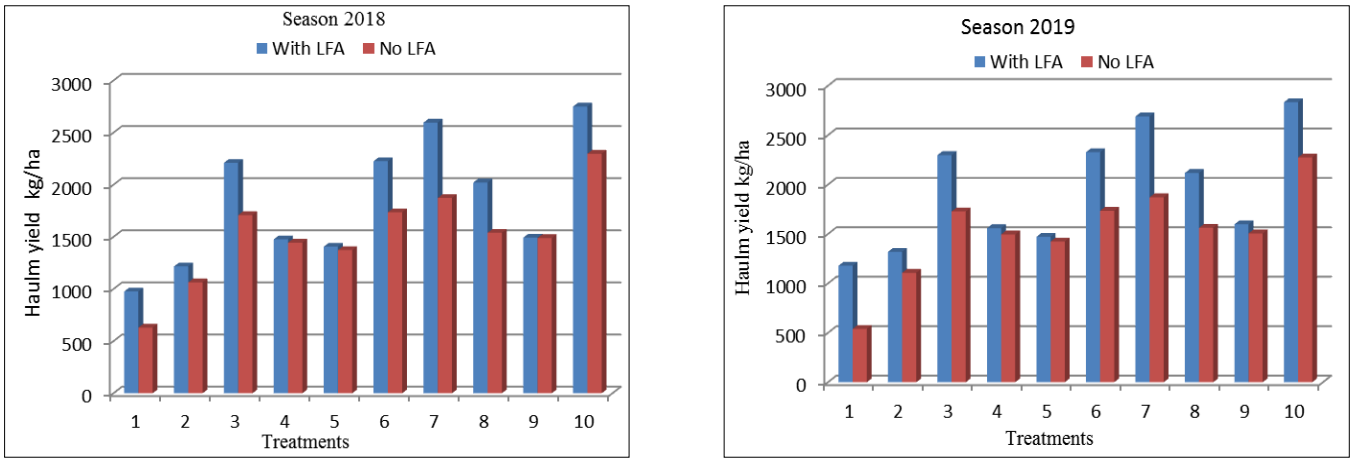

Fig 1 Effect of residual effect of LFA, organics and fertilizers on haulm yield of green gram

Table 3 Effect of residual effect of lignite fly ash, organic and inorganic fertilizer on nutrient uptake by haulm of green gram (kg ha^{-1})

Treatments	N uptake						P uptake						K uptake					
	2018			2019			2018			2019			2018			2019		
	+LFA	-LFA	Mean	+LFA	-L FA	Mean	+L FA	- LFA	Mean	+LFA	-LFA	Mean	+LFA	-LFA	Mean	+LFA	-LFA	Mean
T_1	10.01	6.07	8.04	13.40	4.51	8.95	0.83	0.44	0.66	1.34	0.27	0.80	10.03	6.20	8.11	14.05	5.36	9.71
T_2	13.00	10.67	11.83	15.34	11.36	13.35	1.16	0.92	1.04	1.80	1.03	1.41	14.24	11.23	12.73	17.08	11.03	14.06
T_3	40.83	29.65	35.24	34.78	22.66	28.72	3.85	2.44	3.14	4.57	2.66	3.61	29.40	22.30	25.84	32.63	23.04	27.84
T_4	16.41	15.04	15.72	18.27	16.15	17.21	1.87	1.67	1.77	2.58	2.01	2.30	18.88	16.84	17.86	21.09	18.12	19.60
T_5	14.88	14.34	14.61	17.15	14.73	15.94	1.52	1.35	1.44	2.06	1.52	1.79	17.17	15.37	16.27	19.18	16.20	17.69
T_6	41.02	30.90	35.96	43.57	24.61	34.09	3.86	2.59	3.23	4.76	2.71	3.74	22.57	17.20	19.87	33.78	23.56	28.67
T_7	49.38	33.65	41.51	52.05	35.85	43.95	4.59	3.31	3.95	5.40	3.84	4.62	30.17	25.71	27.94	40.05	23.29	31.67
T_8	29.09	20.67	24.88	31.00	18.95	24.97	3.17	2.17	2.67	4.31	2.32	3.31	38.20	18.47	21.21	29.30	19.99	24.65
T_9	19.48	17.32	18.40	21.53	16.60	19.06	2.01	1.86	1.94	2.54	2.04	2.44	26.65	17.72	22.19	21.64	18.56	20.10
T_{10}	49.39	43.18	46.28	55.63	44.19	49.91	5.39	4.26	4.82	5.66	4.68	5.17	40.97	32.31	36.59	42.52	34.06	38.29
Mean	28.35	22.15		30.27	20.96		2.83	2.10		3.53	2.31		24.82	18.32		27.13	19.32	
	F	T	F×T	F	T	F×T	F	T	F×T	F	T	F×T	F	T	F×T	F	T	F×T
SE_D	1.37	3.08	4.35	0.51	1.14	1.62	0.16	0.36	0.52	0.06	0.15	0.21	1.17	2.63	3.72	1.34	3.01	4.26
CD(p=0.05)	2.79	6.23	8.82	1.04	2.32	3.28	0.33	0.74	1.05	0.13	0.30	0.43	2.38	5.33	7.55	2.73	6.11	8.64

Nutrient uptake

Nutrients uptake (N, P, and K) were significantly increased due to residual effect of LFA, organic and inorganic fertilizers which were applied separately or in combination over control in both years 2018 and 2019.

Haulm uptake

The residual effect of LFA alone or with organics and fertilizer (+LFA) recorded higher total N, P and K uptake of 28.35 and 30.27 kg ha^{-1} (N), 2.83 and 3.53 kg ha^{-1} (P), 24.82 and 27.13 kg ha^{-1} (K) in 2018 and 2019 respectively over no

fly ash (-LFA) of 22.15 and 20.96 kg ha^{-1} (N), 2.10 and 2.31 kg ha^{-1} (P) and 18.32 and 19.32 kg ha^{-1} (K) (Table 3). Integrated application of 100% N recorded higher nutrients uptake by haulm over 50% N. Interaction effect between lignite fly ash with different organics and fertilizer on haulm N, P, and K uptake was significant in both years 2018 and 2019. The residual effect of combined application of 100% NPK + 10 t LFA + 10 t SPM ha^{-1} registered maximum nutrients uptake by haulm of 49.39 and 55.63 kg ha^{-1} (N), 5.39 and 5.66 kg ha^{-1} (P) and 40.97 and 40.52 kg ha^{-1} (K). At all treatments NPK uptake showed higher in the presence of LFA compared to no LFA.

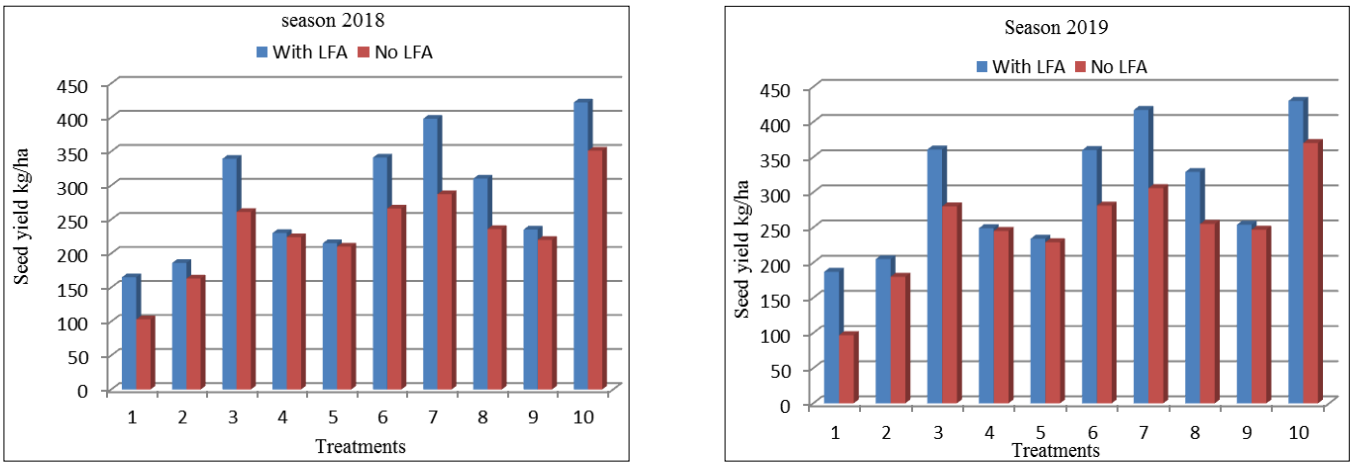

Fig 2 Effect of residual effect of LFA, organics and fertilizers on seed yield of green gram

Table 4 Effect of residual effect of lignite fly ash, organic and inorganic fertilizer on nutrient uptake by seed of green gram (kg ha^{-1})

Treatments	N uptake						P uptake						K uptake					
	2018			2019			2018			2019			2018			2019		
	+LFA	-LFA	Mean	+LFA	-L FA	Mean	+L FA	- LFA	Mean	+LFA	-LFA	Mean	+LFA	-LFA	Mean	+LFA	-LFA	Mean
T_1	3.12	2.66	1.82	4.09	1.82	2.95	0.26	0.15	0.21	0.32	0.11	0.21	1.38	0.78	1.08	1.68	0.58	1.13
T_2	3.68	4.24	3.55	5.14	4.24	4.69	0.36	0.29	0.33	0.44	0.35	0.39	1.57	1.25	1.41	1.91	1.65	1.13
T_3	8.49	7.67	7.67	10.12	7.67	8.89	0.82	0.62	0.72	1.09	0.70	0.89	3.19	2.37	2.78	3.58	2.64	3.11
T_4	5.52	6.13	5.42	6.78	6.13	6.45	0.46	0.44	0.45	0.58	0.52	0.55	2.02	1.96	1.99	2.45	2.25	2.35
T_5	5.02	5.70	4.91	6.06	5.70	5.88	0.42	0.39	0.40	0.49	0.49	0.49	1.79	1.75	1.77	2.19	2.02	2.10
T_6	9.52	8.22	8.53	10.95	8.22	9.58	0.88	0.65	0.76	1.06	0.69	0.88	3.29	2.45	2.87	3.64	2.75	3.19
T_7	12.46	9.65	10.40	13.65	9.65	11.65	1.10	0.74	0.92	1.26	0.82	1.04	4.08	2.79	3.43	4.39	3.11	3.75
T_8	7.93	6.75	6.91	9.23	6.75	7.99	0.73	0.55	0.64	0.90	0.60	0.75	2.93	2.16	2.54	3.26	2.34	2.80
T_9	5.73	6.43	5.52	6.97	6.43	6.70	0.49	0.45	0.47	0.65	0.51	0.58	2.18	2.02	2.10	2.39	2.24	2.31
T_{10}	13.45	11.89	12.19	14.77	11.89	13.33	1.17	0.95	1.06	1.39	1.06	1.22	4.61	3.45	4.03	5.30	3.93	4.61
Mean	7.49	6.85		8.77	6.85		0.67	0.52		0.82	0.58		2.70	2.10		3.08	2.34	
	F	T	F×T	F	T	F×T	F	T	F×T	F	T	F×T	F	T	F×T	F	T	F×T
SE_D	0.20	0.44	0.63	0.16	0.35	0.50	0.03	0.06	0.09	0.007	0.01	0.02	0.14	0.33	0.46	0.05	0.11	0.16
CD(p=0.05)	0.40	0.91	1.28	0.32	0.72	1.02	0.06	0.13	0.19	0.01	0.03	0.04	0.29	0.66	0.94	0.16	0.22	0.32

Seed uptake

Nutrients uptake was significantly higher due to residual effect of LFA alone or in combination with organics and fertilizer (+LFA) 7.49 and 8.77 kg ha^{-1} (N), 0.67 and 0.82 kg ha^{-1} (P), 2.70 and 3.08 kg ha^{-1} over no lignite fly ash (-LFA) 6.85 and 6.85 kg ha^{-1} (N), 0.52 and 0.58 kg ha^{-1} (P) and 2.10 and 2.34 kg ha^{-1} (K) (Table 4). The interaction effect between lignite fly ash with different organics and fertilizer on haulm N, P, and K uptake was significant in both years 2018 and 2019. The greatest NPK uptake by green gram seed noticed with residual incorporation of 100% NPK + 10 t LFA ha^{-1} + 10 t SPM ha^{-1} of 13.45 kg ha^{-1} (N), 1.17 kg ha^{-1} (P) and 4.61 kg ha^{-1} (K) in 2018 and 14.77 kg ha^{-1} (N), 1.39 kg ha^{-1} (P) and 5.30 kg ha^{-1} (K) in 2019, which was on par with T_7 (100% NPK + 10 t LFA ha^{-1} + 10 t FYM ha^{-1}) as a residual effect in 2018 but was superior to rest of the treatments in 2019 [20]. The residual effect of the application of organics and fertilizers improved nutrient uptake that might be due to supply more nutrients due to its release from organic manures through the decomposition process, depending on the type of organic materials. Similarly, the residual effect of fly ash led to increased nutrient uptake due to presence a number of plant nutrient in fly ash [21], and also due to existence considerable concentration of Si in fly ash which leads to liberated more phosphorus [22] and makes it available to the plants, which leads to more its uptake.

CONCLUSIONS

From the aforementioned investigation it could be concluded that combined application of lignite fly ash individually or with organics and fertilizers together to preceding rice crop showed a significant effect on yield characters, yield, and N, P, and K uptake of succeeding green gram crop. The residual effect of integrated lignite fly ash along with organics and fertilizers recorded higher values in all testing parameters of a green gram over no lignite fly ash treatments in the first and second years of the experiment.

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