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Effect of Manures and Phosphorus on Yield and Quality under Rice-Blackgram Cropping Sequence

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted on phosphorus dynamics in relation to nutrient management in rice- blackgram cropping sequence with respect to yield and quality as influenced by effect of organic manures and inorganic phosphorus at Agricultural College Farm, Bapatla. The results revealed that grain yield of rice was significantly higher with the application of 100% RDNK in combination with *Dhaincha* @10t ha^{-1} (M_3) and it was on par with that of application of RDNK along with sunhemp @10t ha^{-1} (M_2). However significantly lower was recorded in RDNK alone (M_0) during both the years of the study. Among the P levels, the treatment P_5 (120 kg P_2O_5 ha^{-1}) recorded significantly highest grain yield and it was on par with P_4 (90 kg P_2O_5 ha^{-1}) and P_3 (60 kg P_2O_5 ha^{-1}) and lowest was recorded in P_1 (0 kg P_2O_5 ha^{-1}). In succeeding blackgram seed yield was significantly influenced by the organic manures and phosphorus levels imposed to preceding rice crop. The seed yield was significantly higher with the application of 100% RDNK in combination with *Dhaincha* @10t ha^{-1} (M_3) and it was on par with that of application of RDNK along with sunhemp @10t ha^{-1} (M_2) and RDNK+ FYM @ 5t ha^{-1} (M_1). However significantly lower was

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recorded in RDNK alone (M_0) during both the years of the study. Among the P levels, the treatment P_4 (90 kg P_2O_5 ha^{-1}) recorded significantly highest seed yield and it was on par with P_5 (120 kg P_2O_5 ha^{-1}), P_3 (60 kg P_2O_5 ha^{-1}) and P_2 (30 kg P_2O_5 ha^{-1}), while lowest was recorded in P_1 (0 kg P_2O_5 ha^{-1}). Regarding quality parameters of rice grain *viz*., amylose and protein were recoeded significantly higher in RDNK+*Dhaincha* @10t ha^{-1} (M_3) and this was on par with that of application of RDNK along with sunhemp @10t ha^{-1} (M_2), while M_2 was remain on par with RDNK+ FYM @ 5t ha^{-1} (M_1). Among the P levels, the treatment P_5 (23.86 and 24.71%) registered significantly higher amylose content and lower was registered in P_1 (21.59 and 22.43%). However, protein content was slightly increased from 0 to 120 kg P_2O_5 ha^{-1} but not significantly differed. Similarly the data regarding influence of organics and P levels applied to preceeding rice crop on protein content of succeeding blackgram followed same trend as in rice.

Keywords: Yield; quality; organic manures; phosphorus fertilizer; rice-blackgram sequence.

1. INTRODUCTION

“Rice–blackgram is the most predominant cropping system in coastal region of Krishna Agroclimatic Zone of Andhra Pradesh. Impaired soil fertility due to indiscriminate application of nutrients through the fertilizers has become major threat for the productivity. In intensive cropping systems, maintenance of soil fertility is the major criteria to sustain the crop yields for longer period of time as these systems, deplete substantial amount of nutrients from the soil throughout year. The main principle of maintaining the soil fertility status is to annually replenish those nutrients which are removed by the crops from the field. For maintaining fertility status of soil on a long run, we should dependent on the different nutrient sources rather than chemical fertilizers alone. Whereas, integration of chemical fertilizers with organic manures (INM) is one of the best management practices to maintain the soil fertility on a long run to achieve sustainable crop yields with less environmental pollution to the ecosystem” [1].

“Phosphorus is an essential, irreplaceable element in all living cells and without it, there would be no living thing on the earth. It has structural function in macromolecules, metabolic pathways and degradation and involved in a wide range of plant processes starting from permitting cell division to the development of a good root system, ensuring timely and uniform ripening of the crop. But the main problem concerning phosphatic fertilizers is its fixation with soil complex within a short period of application rendering more than two thirds unavailable. So, it is necessary to know the optimum dose of phosphorus fertilizer for maximum yield. Phosphorus fertilization is required to sustain optimum crop yields” [2].

2. MATERIALS AND METHODS

A field experiment entitled “Phosphorus dynamics in relation to nutrient management in rice-blackgram cropping sequence” was conducted for two consecutive years (2017-2018 and 2018-2019) at Agricultural College Farm, Bapatla. The experimental soil was clay loam in texture, slightly alkaline in reaction, low in organic carbon and available nitrogen, medium in available phosphorus and high in available potassium. The micronutrients suchas Fe, Mn, Zn and Cu were above their critical levels. The experiment was laid out in a split plot design and replicated thrice. The treatments consisted of RDNK (M_0), RDNK+FYM @ 5t ha^{-1} (M_1), RDNK+sunhemp @ 10t ha^{-1} (M_2) and RDNK+*Dhaincha* @ 10t ha^{-1}(M_3) as main plots and five phosphorus levels to rice crop comprising of 0 kg P_2O_5 ha^{-1} (P_1), 30 kg P_2O_5 ha^{-1} (P_2) and 60 kg P_2O_5 ha^{-1} (P_3), 90 kg P_2O_5 ha^{-1} (P_4) and 120 kg P_2O_5 ha^{-1} (P_5) as sub- plot treatments. These treatments were imposed to rice crop during *kharif* season. The *rabi* experiment was continued on the same site without disturbing the soil for succeeding blackgram crop to study residual effect of organic manures and P levels applied to preceeding rice crop. Popular cultivars of rice and blackgram *viz*., BPT-5204 and TBG -104 respectively, were chosen for the study. The data collected on yield and quality parameters of rice and blackgram as described below.

2.1 Grain Yield

The crop harvested from each net plot was bundled up separately and allowed for drying in sun and threshed individually plot wise by using pedal operated paddy thresher. Cleaning of the grains was done after threshing and then dried in sun to a constant weight to record the final yield.

Grain yields from the labeled hills were added to the corresponding plot yields before expressing the final grain yield in t ha^{-1} during both the years of study.

2.2 Seed Yield

At maturity, all the above ground blackgram biomass from each net plot area was harvested and transported to the threshing floor. After drying in sun for seven days, the biomass from each plot was weighed before subjecting it for threshing. After threshing, weight of seeds was recorded plot-wise and expressed in kg ha^{-1}.

2.3 Amylose Content

Amylose, a linear fraction of starch has a major influence on cooking and eating quality characteristics of rice. It also plays an important role in determining the texture of cooked rice. The powdered rice grain sample (100 mg) was taken. To this, 1 ml of 95% ethanol and 9ml of 1N NaOH was added. The sample was kept over night at room temperature to gelatinize the starch. Later, it was cooled and transferred to 100 ml volumetric flask. The total volume was made upto 100 ml with distilled water and mixed well. Pippetted out 0.5 ml aliquot from this solution and 9.2 ml of distilled water. The solution was mixed well on a vortex mixture and the colour developed was read at 620 nm against reagent blank. The standard curve was prepared by using potato amylose in range of 40-200 µg. Grain amylase content was estimated as per the procedure described by Julino [3] and expressed as percentage.

2.4 Protein Content

The protein content of grain was estimated by multiplying the nitrogen content with the factor 6.25 [4] and expressed as percentage.

Protein content (%) = Total Nitrogen (N) content (%) x 6.25

3. RESULTS AND DISCUSSION

3.1 Grain Yield

Data pertaining to grain yield as influenced by various organic manure treatments and phosphorus levels were presented in Table 1. During both the years, the grain yield differed significantly due to organic manure treatments and phosphorus levels, however interaction of organic manures and phosphorus levels not significantly differed. Critical examination of the data indicated that the grain yield of rice during both the years were significantly increased due to application of organics along with RDNK over RDNK alone. Application of *Dhaincha* @10t ha^{-1} + RDNK (M_3) recorded the highest grain yield (5524 and 5801 kg ha^{-1}) and it was on par with sunhemp 10t ha^{-1} + RDNK (M_2**-** 5382 and 5651 kg ha^{-1}) and these two treatments were significantly superior over FYM along with RDNK (M_1-4684 and 4949 kg ha^{-1}) and RDNK alone (M_0**-** 3943 and 4140 kg ha^{-1}) during 2017 and 2018, respectively. Incorporation of green manure might have provided biological nitrogen fixed in the soil leading to continuous supply of nutrients in phased manner into the soil solution ultimately increasing nutrient supply to the rice crop. The increased grain yield due to green manure incorporation might be due to the cumulative effect of substantial improvement in growth characters like plant height, drymatter accumulation, higher yield attributes *viz*., panicle length, number of filled grains and test weight. The improved growth and yield attributes contributed towards the increase in yield of rice in green manure plots. Addition of different green manures enhanced the organic carbon percentage of the soil which is a key factor determining soil fertility and productivity. This increase in organic matter content in the soil improved the physical properties (bulk density, water holding capacity and infiltration rate) of the soil thereby increase in growth parameters, yield attributes and yield [5].

Among the phosphorus levels, the significantly higher grain yield was recorded in P_5 (120 kg P_2O_5 ha^{-1}) (5333 and 5600 kg ha^{-1}) and it was on par with P_4 (90 kg P_2O_5 ha^{-1}) (5228 and 5489kg ha^{-1}) and P_3 (60 kg P_2O_5 ha^{-1}) (5144 and 5401kg ha^{-1}) treatments and these three treatments were significantly superior over 30 kg P_2O_5 (P_2**-**4628 and 4859 kg ha^{-1}), 0 kg P_2O_5 (P_1**-** 4085 and 4290 kg ha^{-1}) during 2017 and 2018, respectively. However the significantly lower grain yield was recorded in P_1 which received 0 kg P_2O_5 during both the years of study. The improvement in grain yield of rice with increase in the level of phosphorus might be due to the manifestation of elevated level of phosphorus on growth and yield parameters resulting in the superior performance of rice over the lower levels. The positive response of rice at higher levels of phosphorus application could be attributed to the overall improvement in crop growth by accumulating more drymatter in yield attributes, which might have enabled the plants to absorb more nutrients in order to prepare more photosynthates. Further, their translocation to sink finally might have reflected in higher yield. The beneficial role of phosphorus in enhancing the yield components and in-turn the yield was very well established by different research workers such as Ashiana et al. [6] and Sampath et al. [7].

3.2 Seed Yield (kg ha^{-1})

Data pertaining to seed yield as influenced by different organic manures and P levels were presented in the table 2. Data set out in the above tables revealed significant differences due to organic manures and P levels. However the interaction effect between organic manures and P levels failed to produce any measurable variation. The seed yield of *rabi* blackgram was significantly higher with M_3 (826 and 903) and this was on par with M_2 (819, 893) and M_1 (784 and 856 kg ha^{-1}) and these three treatments were significantly superior over M_0 (690 and 757 kg ha^{-1}) during 2018 and 2019, respectively. The percent increase of seed yield of M_3 over M_0 treatment was 19.7 and 19.2 in 2018 and 2019, respectively. The increase in the seed yield with *Dhaincha,* sunhemp and FYM over the RDNK might be due to more drymatter accumulation, more number of branches, higher number of plants^{-1}, seeds pod^{-1} and higher test weight recorded with those treatments. Similar results were obtained by Gajendrasingh et al. (2016) who reported that “conjunctive use of organic manures had showed the highest seed yield compared to inorganics only”. Shashikumar et al. [8] had also stated that “highest yields were obtained with organics in conjunction with inorganics. Growth regulators combinedly effect the grain yield of blackgram crop”. Geetha and Velayutham [9] also supported that “the fertilizer application methods followed in the preceding rice crop did exert significant variation in the grain yield of succeeding blackgram crop and the percent of yield increase due to fertilizer application to blackgram was 12% over application of the recommended dose of fertilizer to preceding rice crop. The increase in yield might be due to enhancement in growth and yield parameters as well as uptake of nutrients by crop. Obviously, the cumulative effects of these parameters might have contributed to increased grain yield potential of the crop”.

With increase in the phosphorus levels to *kharif* rice, there was a gradual and significant increase in the seed yield of *rabi* blackgram. Significantly higher seed yield was registered with 90 kg P_2O_5 ha^{-1} (835 and 918 kg ha^{-1}) and lower was registered with 0 kg P_2O_5 ha^{-1} (717 and779 kg ha^{-1}) to preceeding rice crop during 2018 and 2019, respectively. Whereas the treatments P_4 was on par with P_5 and P_3, while P_3 was on par with P_2, P_2 was on par with P_1. Similar reports of increased yield of *rabi* blackgram at higher doses of phosphorus to preceeding rice was also reported by various researchers like Prathibhasree et al. [10]. The increase in the seed yield of succeeding blackgram with phosphorus applied to rice could be ascribed to the increased residual available phosphorus which might have helped in developing profused root system resulting in increased nutrient uptake, higher drymatter accumulation and translocation of photosynthates from vegetative parts to seeds. These results confirmed with the findings of Shubhangi et al. [11]. Significantly increased seed yield was recorded with the application of phosphorus which might be the fact that excess assimilates stored in the leaves and later translocated in to seeds at the time of senescence, ultimately led to higher seed yield.

3.3 Quality of Rice Grain

3.3.1 Amylose content

Data pertaining to amylose content was presented in table 3 and depicted in Fig. 1a. Significantly higher amylose content was recorded by the treatment RDNK + *Dhaincha* @ 10 t ha^{-1} (M_3- 23.89 and 24.98%) and it was on par with RDNK+ sunhemp @ 10 t ha^{-1} (M_2- 23.25 and 24.28%), while M_2 was on par with RDNK + FYM @ 5 t ha^{-1} (M_1- 22.83 and 23.71%) during 2017 and 2018, respectively. However the significantly lower amylose content was recorded in RDNK alone (M_0-21.63 and 22.00%) during both the years of study.

Among the P levels, the amylose content was ranged from 21.59 to 23.86% and 22.43 to 24.71% during 2017 and 2018, respectively. The treatment P_5 (23.86 and 24.71%) registered significantly higher amylose content and lower was registered in P_1 (21.59 and 22.43%). Whereas, the treatment P_5 was on par with P_4 and P_3. However, interaction among organic manures and P levels were not significantly differed. The increase in amylose content among the P levels might be due to higher availability; absorption and uptake of nutrients thereby increase of nutrients in grain and increased the amylase content. The present results were in agreement with the findings of Hemalatha et al. [12]. Starch is biosynthesized from adenine disphosphate glucose of which N and P are the constituents. Hence, amylose content increased due to application of nutrients was quite natural [5]. The lowest amylose content was registered in P_1 during both the years of study. This might be due to inadequate nutrient supply during critical crop growth periods as explained earlier with the findings of Jana et al. [13]. The maximum amylase content, which might be due to steady grain filling, dense packing of grain as reflected in 1000 grain weight of grain together with better nutrient uptake by the grain. Such results were also reported by Sangeetha et al. [14] and Ashiana et al. (2021).

3.3.2 Protein content

Data pertaining to protein content of rice grain as influenced by various organic manure treatments and phosphorus levels are presented in Table 4 and illustrated in Fig. 1b. During both the years, the protein content of rice grain differed significantly due to organic manure treatments only while phosphorus levels as well as interaction of organic manures and phosphorus levels did not cause any measurable differences.

Similar results were also reported by Ram et al. (2021). During both the years of investigation significantly highest protein content was observed in the treatment where 100% RDNK was applied in combination with *Dhaincha* 10 t ha^{-1} (M_3- 6.78 and 7.34%). However, this treatment was remain on par with RDNK+ sunhemp 10 t ha^{-1} (M_2- 6.60 and 7.16%), RDNK+ FYM 5 t ha^{-1} (M_1-6.02 and 6.46%). Significantly lower protein content was recorded in RDNK alone (M_0-4.81 and 5.19%). There was an increase in protein content in organic manure applied treatments than RDNK alone treatment might be due to the addition of green leaf manures and FYM build resulting up of nitrogen in the soil that is utilized by the plant and finally accumulated in grain.

The protein content was increased with the increased levels of P from 0 kg P_2O_5 ha^{-1} (P_1- 5.83 to 6.24%) to 120 kg P_2O_5 ha^{-1} (P_5- 6.32 to 6.72%) during *kharif* 2017 and 2018 respectively, these differences were not statistically significant. However interaction effect was not statistically significant. The increase in protein content might be due to the fact that higher nutrient availability from organic manures along with inorganic fertilizers resulted in perfect grain filling process without air vacuoles [15].

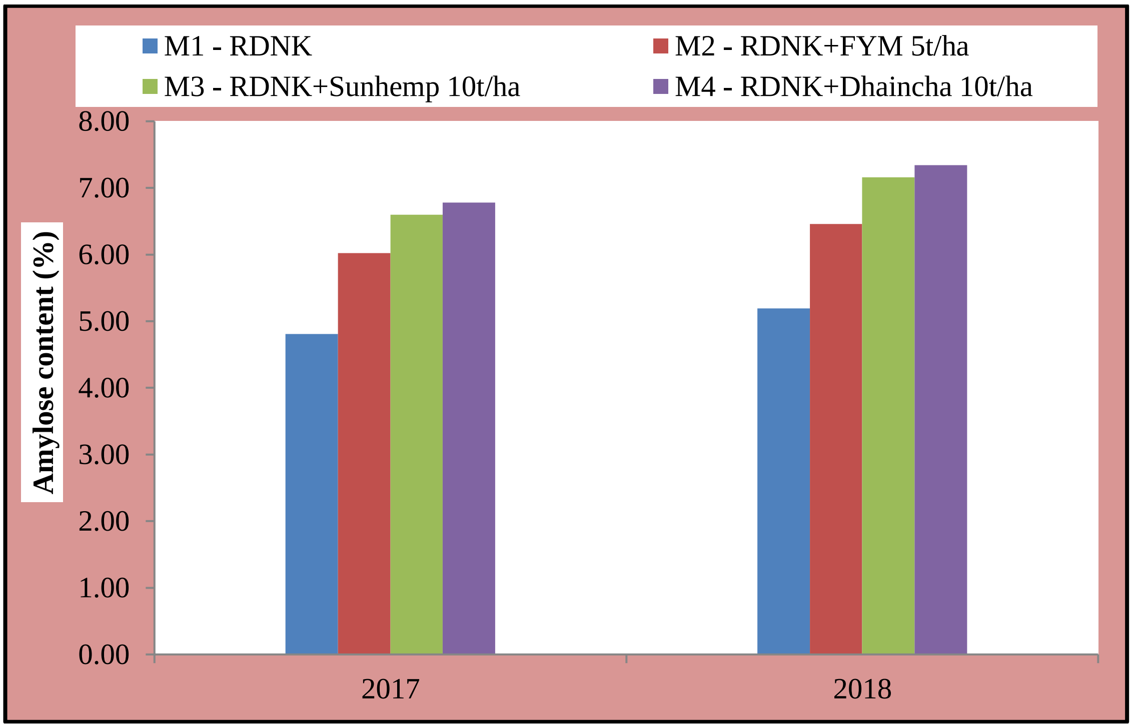

Fig. 1a. Effect of organic manures on amylose content (mean values) at different growth stages of rice

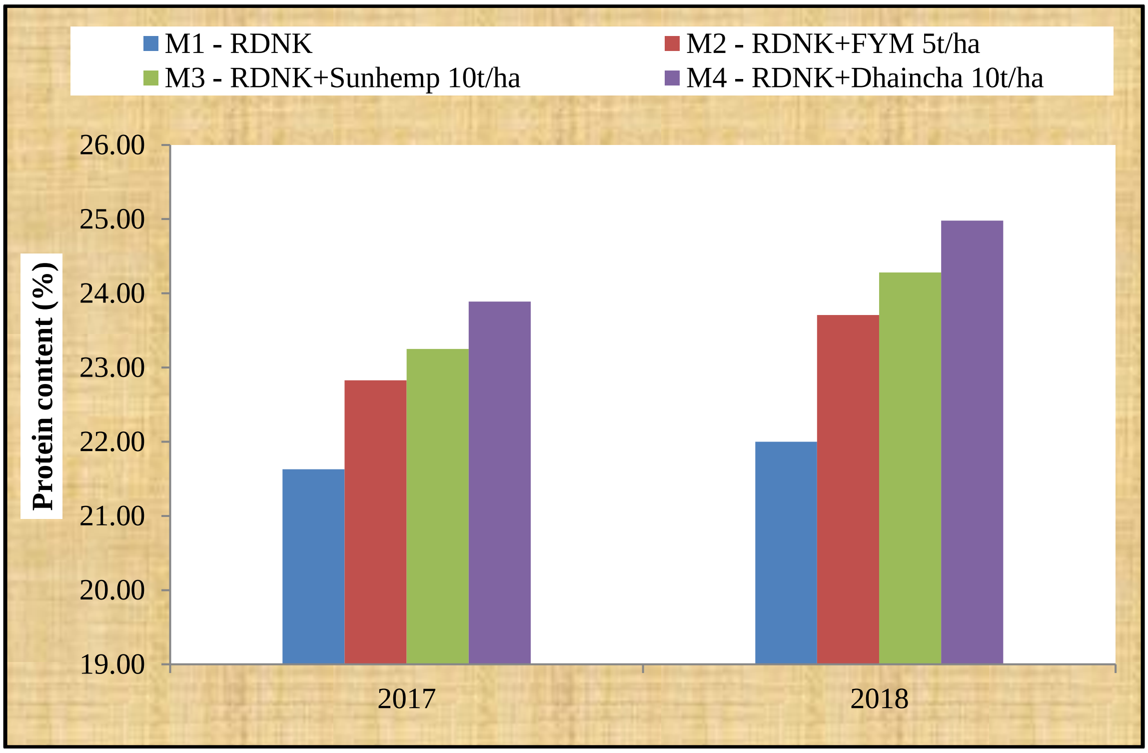

Fig. 1b. Effect of organic manures on protein content (mean values) at different growth stages of rice

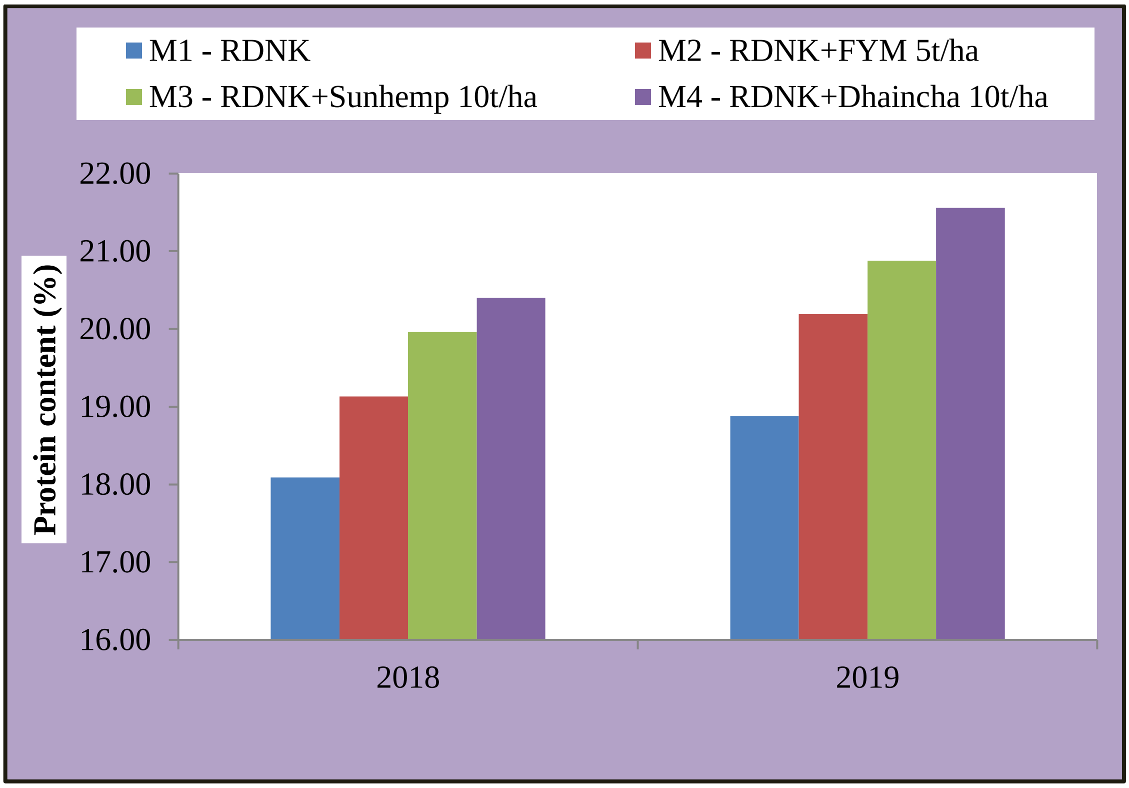

Fig. 2a. Residual effect of organic manures on protein content (%) under succeeding blackgram in rice- blackgram cropping sequence

Table 1. Effect of organic manures and inorganic P fertilizer on grain yield (kg ha^{-1}) of rice

P levels (kg P_2O_5 ha^{-1})	*Kharif* 2017				Mean	*Kharif* 2018				Mean
	Organic manures					Organic manures				
	M_0	M_1	M_2	M_3		M_0	M_1	M_2	M_3	
P_1– 0	3231	3872	4615	4622	**4085**	3393	4066	4846	4855	**4290**
P_2– 30	3693	4372	5113	5333	**4628**	3878	4591	5369	5599	**4859**
P_3– 60	4159	4942	5673	5800	**5144**	4367	5189	5957	6090	**5401**
P_4– 90	4302	5006	5716	5887	**5228**	4517	5256	6002	6181	**5489**
P_5– 120	4329	5230	5794	5980	**5333**	4546	5491	6083	6279	**5600**
Mean	**3943**	**4684**	**5382**	**5524**		**4140**	**4949**	**5651**	**5801**	
	SEm ±		**CD (p=0.05)**		**CV (%)**	**SEm ±**		**CD (p=0.05)**		**CV (%)**
M	127.85		442		10.1	124.45		431		9.4
P	159.44		459		11.3	164.95		475		11.1
M at P	318.88		NS			329.90		NS		
P at M	312.56		NS			320.24		NS		

M_0- No Organic manure; M_1- RDNK+FYM 5 t ha^{-1}; M_2- RDNK+Sunhemp 10 t ha^{-1}; M_3- RDNK+Dhaincha 10 t ha^{-1}

Table 2. Residual effect of organic manures and inorganic P fertilizer on seed yield (kg ha^{-1}) of succeeding blackgram in rice based cropping sequence

P levels (kg P_2O_5 ha^{-1})	*Rabi* 2018				Mean	*Rabi* 2019				Mean
	Organic manures					Organic manures				
	M_0	M_1	M_2	M_3		M_0	M_1	M_2	M_3	
P_1– 0	621	719	760	767	**717**	681	784	812	836	**779**
P_2– 30	642	746	784	794	**742**	704	813	855	866	**810**
P_3– 60	697	807	831	836	**793**	765	884	905	911	**866**
P_4– 90	755	838	872	876	**835**	827	914	968	964	**918**
P_5– 120	734	809	846	857	**812**	805	882	923	934	**886**
Mean	**690**	**784**	**819**	**826**		**757**	**856**	**893**	**903**	
	SEm ±		**CD (p=0.05)**		**CV (%)**	**SEm ±**		**CD (p=0.05)**		**CV (%)**
M	27.77		89		13.8	27.57		95		12.5
P	23.03		66		10.2	26.03		75		10.6
M at P	46.07		NS			52.06		NS		
P at M	49.69		NS			54.11		NS		

M_0- No Organic manure; M_1- RDNK+FYM 5 t ha^{-1}; M_2- RDNK+Sunhemp 10 t ha^{-1}; M_3- RDNK+Dhaincha 10 t ha^{-1}

Table 3. Effect of organic manures and inorganic P fertilizer on amylose content (%) of rice

P levels ($kg\ P_2O_5\ ha^{-1}$)	*Kharif* 2017				Mean	*Kharif* 2018				Mean
	Organic manures					Organic manures				
	M_0	M_1	M_2	M_3		M_0	M_1	M_2	M_3	
P_1– 0	20.84	21.44	21.77	22.31	**21.59**	21.20	22.31	22.81	23.40	**22.43**
P_2– 30	20.43	22.53	22.87	23.52	**22.34**	20.81	23.40	23.90	24.61	**23.18**
P_3– 60	21.54	23.14	23.55	24.20	**23.11**	21.89	24.02	24.59	25.29	**23.95**
P_4– 90	22.52	23.42	23.86	24.60	**23.60**	22.90	24.29	24.92	25.69	**24.45**
P_5– 120	22.83	23.63	24.18	24.81	**23.86**	23.22	24.52	25.19	25.92	**24.71**
Mean	**21.63**	**22.83**	**23.25**	**23.89**		**22.00**	**23.71**	**24.28**	**24.98**	
	SEm ±		**CD (p=0.05)**		**CV (%)**	**SEm ±**		**CD (p=0.05)**		**CV (%)**
M	0.19		0.65		8.1	0.23		0.81		10.8
P	0.25		0.71		6.1	0.23		0.67		7.7
M at P	0.49		NS			0.46		NS		
P at M	0.48		NS			0.47		NS		

M_0- No Organic manure; M_1- RDNK+FYM 5 t ha^{-1}; M_2- RDNK+Sunhemp 10 t ha^{-1}; M_3- RDNK+Dhaincha 10 t ha^{-1}

Table 4. Effect of organic manures and inorganic P fertilizer on protein content (%) of rice

P levels ($kg\ P_2O_5\ ha^{-1}$)	*Kharif* 2017				Mean	*Kharif* 2018				Mean
	Organic manures					Organic manures				
	M_0	M_1	M_2	M_3		M_0	M_1	M_2	M_3	
P_1– 0	4.60	5.83	6.34	6.55	**5.83**	4.98	6.27	6.91	7.11	**6.32**
P_2– 30	4.73	5.94	6.54	6.67	**5.97**	5.10	6.38	7.10	7.23	**6.45**
P_3– 60	4.79	6.06	6.63	6.81	**6.07**	5.17	6.50	7.19	7.38	**6.56**
P_4– 90	4.94	6.10	6.67	6.88	**6.15**	5.31	6.54	7.23	7.44	**6.63**
P_5– 120	5.00	6.17	6.81	6.98	**6.24**	5.38	6.60	7.38	7.54	**6.72**
Mean	**4.81**	**6.02**	**6.60**	**6.78**		**5.19**	**6.46**	**7.16**	**7.34**	
	SEm ±		**CD (p=0.05)**		**CV (%)**	**SEm ±**		**CD (p=0.05)**		**CV (%)**
M	0.22		0.78		11.2	0.29		1.01		15.3
P	0.28		NS		12.9	0.26		NS		13.7
M at P	0.56		NS			0.52		NS		
P at M	0.55		NS			0.55		NS		

M_0- No Organic manure; M_1- RDNK+FYM 5 t ha^{-1}; M_2- RDNK+Sunhemp 10 t ha^{-1}; M_3- RDNK+Dhaincha 10 t ha^{-1}

Table 5. Residual effect of organic manures and inorganic P fertilizer on protein (%) of succeeding blackgram in rice based cropping sequence

P levels (kg P_2O_5 ha^{-1})	*Rabi* 2018				Mean	*Rabi* 2019				Mean
	Organic manures					Organic manures				
	M_0	M_1	M_2	M_3		M_0	M_1	M_2	M_3	
P_1– 0	17.88	18.94	19.75	20.06	**19.16**	18.29	19.63	20.28	20.74	**19.74**
P_2– 30	18.00	19.06	19.88	20.25	**19.30**	18.53	19.89	20.60	21.19	**20.05**
P_3– 60	18.13	19.13	20.00	20.44	**19.42**	19.03	20.21	21.00	21.66	**20.48**
P_4– 90	18.19	19.19	20.06	20.56	**19.50**	19.21	20.47	21.19	22.00	**20.72**
P_5– 120	18.25	19.31	20.13	20.69	**19.59**	19.35	20.72	21.33	22.21	**20.90**
Mean	**18.09**	**19.13**	**19.96**	**20.40**		**18.88**	**20.19**	**20.88**	**21.56**	
	SEm ±		**CD (p=0.05)**		**CV (%)**	**SEm ±**		**CD (p=0.05)**		**CV (%)**
M	0.15		0.53		6.1	0.20		0.68		6.7
P	0.14		NS		5.5	0.29		NS		7.8
M at P	0.29		NS			0.57		NS		
P at M	0.30		NS			0.55		NS		

M_0- No Organic manure; M_1- RDNK+FYM 5 t ha^{-1}; M_2- RDNK+Sunhemp 10 t ha^{-1}; M_3- RDNK+Dhaincha 10 t ha^{-1}

3.4 Quality of Blackgram Seed

3.4.1 Protein content

Data pertaining to protein content as influenced by various organic manure treatments and P levels are presented in Table 5 and illustrated in Fig. 2a. During both the years, the protein content differed significantly due to organic manures only. P levels as well as interaction of organic manures and P levels did not cause any markable differences. During both the years of investigation significantly highest protein content was achieved in the treatment where RDNK+ *Dhaincha* @ 10 t ha^{-1} (M_3- 20.40 and 21.56%). However, this treatment was on par with RDNK+ sunhemp @ 10 t ha^{-1} (M_2- 19.96 and 20.88%), however these two treatments were significantly superior over RDNK+ FYM @ 5 t ha^{-1} (M_1- 19.13 and 20.19) and RDNK alone (M_0- 18.09 and 18.88%) during 2018 and 2019, respectively.

Among the P levels, the protein content was increased with increasing P levels during both the years of study but not significantly differed. The averaged values pertaining to protein content recorded under five phosphorus levels i.e. P_1, P_2, P_3, P_4 and P_5 were 19.16, 19.74, 19.30, 20.05, 19.42, 20.48, 19.50, 20.72, 19.59 and 20.90% in both *rabi* 2018 and 2019, respectively. Aruna and Reddy [15] reported that highest protein were registered with addition of organic manures along with inorganic fertilizer might be due to protein content is dependent on N content of grain thereby increased the protein synthesis under adequate supply of nitrogen [16-18].

4. CONCLUSION

Significantly higher grain and seed yield of rice and blackgram was recorded in the treatment which received 100% RDNK in combination with *Dhaincha* @10t ha^{-1} and the lowest was recorded in RDNK alone. Among the P levels, the treatment P_5 (120 kg P_2O_5 ha^{-1}) recorded significantly higher grain yield and the lowest was recorded in P_1 (0 kg P_2O_5 ha^{-1}) during both the years of study. Where as in succeeding blackgram, among the P levels the highest seed yield was recorded in the treatment P_4 (90 kg P_2O_5 ha^{-1}). Regarding quality parameters of rice grain *viz*., amylase and protein were recoeded significantly higher in RDNK+*Dhaincha* @10t ha^{-1} (M_3) and lowest was recorded in RDNK alone (M_0). Among the P levels, the treatment P_5 registered significantly higher amylose content and lower was registered in P_1. However, protein content was slightly increased from 0 to 120 kg P_2O_5 ha^{-1} but not significantly differed. Similarly the data regarding influence of organics and P levels applied to preceeding rice crop on protein content of succeeding blackgram followed same trend as in rice.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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