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Correlation Between Growth and Yield of Greengram in Drip Fertigation, Fermented Fish Waste, Fermented Egg Product Application under Aerobic Rice (*Oryza sativa* L.)-Greengram (*Vigna radiata* L.) Cropping System in Western Zone of Tamil Nadu

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ABSTRACT

Background: The productivity of greengram (*Vigna radiata* L.) is not adequate to meet the growing global population since mostly all the leguminous crop grown under rainfed condition. In this regard, a research experiment was conducted to investigate the effect of bio fermented products with drip fertigation under aerobic rice (*Oryza sativa* L.) - greengram (*Vigna radiata* L.) cropping system.

Methods: A field experiment was conducted at Wetland farms of Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore during 2019-21. For greengram thirteen treatments with randomized complete block design were imposed in which fermented fish waste and fermented egg product were applied through drip at vegetative stage and peak flowering stage. Surface irrigation was scheduled based on IW/CPE ratio of 0.5 with conventional application of fertilizers.

Result: The experiment results revealed that application of drip fertigation @ 125% RDF+100% PE with FFW registered higher growth parameters (plant height, drymatter production, 50% flowering, LAI), physiological parameters (Crop growth rate, Relative growth rate, SPAD values), yield attributes, yield and cropping system analysis. The results of correlation analysis also showed that the grain yield was positively impacted by the yield parameters.

Key words: Fermented egg product, Fermented fish waste, Growth, Yield.

INTRODUCTION

Pulses, which are the wholesome edible seeds of leguminous plants, are crucial component of the human diet. Blackgram (*Vigna mungo* L.), a kind of pulse, is a significant legume crop grown in tropical and subtropical areas of the world (Kannamreddy *et al*., 2021). Greengram typically records poor yield being cultivated under rice fallow/ mixed cropping/rainfed situation with improper irrigation and nutrient management. Among rice-based cropping systems, rice-pulse cropping system is one of the most important cropping systems. For rice fallow greengram crop, zero tillage is adopted. In zero tillage, soil is not disturbed and soil is opened only for placing the seed. Succeeding crop is sown without any preparatory cultivation in the stubbles of the previous crop. It minimizes the labour and fuel cost. Weeds are controlled by surface application of post-emergence herbicides. The previous crop residue increases the water infiltration and reduces evaporation of soil water.

Higher available N was found with 100% RDF drip fertigation at 15-30 cm depth from the emitters. The concentration of available N distribution in upper soil (0-15 cm) was lower than that of 15-30 cm soil layer. Availability of K was more under 100% RDF at 0-15 cm soil layer from the emitters in rice.

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The bio fermented products obtained from plant or animal sources contains several compounds and mixture of several things such as microorganisms, plant hormones,

plant growth regulating rhizobacteria, enzymes and humic acid trace elements that increases water holding capacity, enhance metabolism, increases antioxidants and regulates plant growth and yield, when applied as foliar spray reduces the micro nutrient deficiencies (Mesquita *et al*., 2012). Fermented fish waste, one of the bio extract products has the capacity to replace chemical fertilizers.

The liquid nature of the product increases the availability of nutrients when it is applied through drip irrigation. Fermented fish waste (FFW) and fermented egg product (FEP) combined with organic fertilizers can be used as an effective substitute for foliar fertilizer because it is safer and it could help in producing more quality farm produce. Soil drenching or foliar application of fermented fish waste increases the uptake and reduces the leaching, supplying required nitrogen to the crop for the production of chlorophyll to maintain plant health, improves the metabolic and cellular activity of greengram (Priyanka *et al*., 2019). The addition of fermented fish waste may be considered as a novel liquid biofertilizer as it promotes growth, nitrogen fixation by increasing root nodulation, enriching the soil with trace elements and microbial community (Hepsibha and Geetha, 2017).

Consequently, considering the above facts, field research was carried out to study the effect of drip fertigation, Fermented fish, egg waste application on growth, yield attributes and yield of greengram under aerobic rice (*Oryza sativa* L.) - greengram (*Vigna radiata* L.) cropping system.

MATERIALS AND METHODS

Details of the experimental site

A field experiment was laid out in Field No. B6 at Wetland farm, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore during 2019 and 2021 situated in Western Agro-Climatic Zone of Tamil Nadu at 11°N latitude, 77°E longitude and at an altitude of 426.7 m above MSL (mean sea level). The experiment was laid out in a randomized complete block design with thirteen treatments and replicated thrice and experimental crop details given Table 1. Treatment details for greengram were T_1 - Drip fertigation (DF) @ 75% Recommended Dose Fertilizer (RDF), 75% Pan Evaporation (PE) with Fermented Fish Waste (FFW) (2 times), T_2 - DF @ 75% RDF, 75% PE with Fermented Egg Product (FEP) (2 times), T_3 - DF @ 100% RDF, 75% PE with FFW (2 times), T_4 - DF @ 100% RDF, 75% PE with FEP (2 times), T_5 - DF @ 125% RDF, 75% PE with FFW (2 times), T_6 - DF @ 125% RDF, 75% PE with FEP (2 times), T_7 - DF @ 75% RDF, 100% PE with FFW (2 times), T_8 - DF @ 75% RDF, 100% PE with FEP (2 times), T_9 - DF @ 100% RDF, 100% PE with FFW (2 times), T_{10} - DF @ 100% RDF, 100% PE with FEP (2 times), T_{11} - DF @ 125% RDF, 100% PE with FFW (2 times), T_{12} - DF @ 125% RDF, 100% PE with FEP (2 times), T_{13} - Surface irrigation with 100% RDF.

Drip laterals of 16 mm OD (250-micron wall thickness) fixed in the sub mains with a lateral spacing of 120 cm. Laterals had emitting point spaced at 30 cm apart with a discharge rate of 4 lph. Flow of water from sub main to laterals were regulated with a control valve in order to regulate the irrigation and fertigation scheduling and the laterals were closed with end cap. Each plot comprised of three laterals for irrigating 12 rows of rice and nine rows of greengram plants. Before sowing of greengram, glyphosate (41% SL) was applied to the experimental field with concentration @ 10 ml litre^{-1} water was applied. Pre-emergence application of pendimethalin @ 1 kg *a.i.* ha^{-1} on 3 DAS followed by one hand weeding during the vegetative period was done, to keep the field weed free till the crop canopy has considerably covered the ground. Recommended dose of fertilizer (RDF) for aerobic rice (150:50:50 NPK kg ha^{-1}) and greengram (25:50:25 NPK kg ha^{-1}) crop was applied and were taken as 100% RDF. In greengram, 50% N and K_2O as basal and remaining as two equal top dressing on 20 and 40 DAS under Conventional method. The fertilizer sources for supplying N, P and K through drip irrigation were urea (46% N), mono ammonium phosphate (12% N, 61% P) and sulphate of potash (50% K), respectively. Each bed consisted of one lateral for irrigating four rows of crops. The required quantity of N, P_2O_5 and K_2O fertilizers as per the treatment were dissolved in water separately. For greengram, fertigation was done through fertigation tank twice in a week starting from 10 to 45 DAS, which was regulated by taps, provided near take-off point of the sub main. Fertigation was carried out in three consecutive steps *viz*., wetting the root zone before fertigation, fertigating the field with water and nutrients. The growth attribute such as plant height, Dry Matter Production, 50% flowering, LAI, Physiological parameters such as SPAD values and RGR were recorded. The details of drip fertigation schedule for split application of fertilizer were given in Table 2 and layout of drip fertigation was given Fig 1.

Correlation is a method for determining the relationship between two variables. The correlation coefficient formula enables the calculation of the connection between two variables and the resulting number describes the accuracy of the expected and actual values. In this article, correlation was employed to identify the relations among grain yield (kg ha^{-1}), plant height (cm), number of branches plant^{-1}, number of pods plant^{-1}, DMP (kg ha^{-1}, leaf area index, number of seeds pod^{-1}, pod weight (g) and its length (cm).

RESULTS AND DISCUSSION

Effect on growth characters

Different drip irrigation and fertigation treatments significantly influenced the growth characters of greengram during both the years of investigation and the data was given in the Table 3. Higher plants height, DMP, were observed in the summer 2020 and the *kharif* 2021 with drip fertigation @ 125% RDF, 100% PE with FFW (2 times), (T_{11}) (60.7 and 57.3 cm) and (4463 kg ha^{-1} and 4169 kg ha^{-1}), respectively, at harvest stage (Srinivasan *et al*., 2019; Balaji *et al*., 2019;

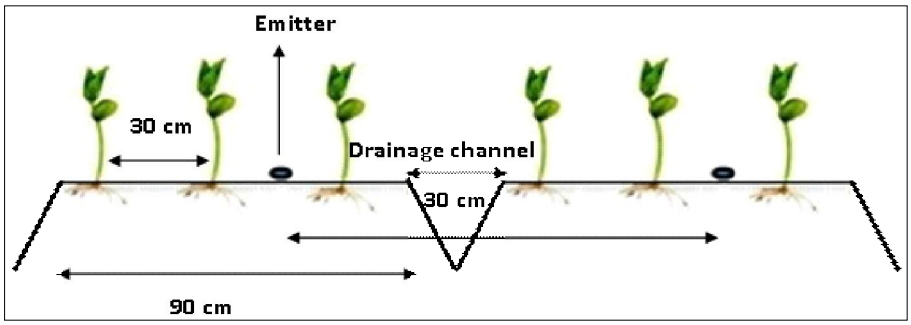


Fig 1: Layout of drip fertigation in greengram crop.

Table 1: Experimental crop details.

Details	2019-20		2020-21	
	Rice	Greengram	Rice	Greengram
Date of sowing	23.9.2019	10.2.2020	02.1.2021	23.6.2021
Date of irrigation and fertigation treatment imposed	04.10.2019	20.2.2020	12.1.2021	03.7.2021
Date of withholding fertigation	20.12.2019	05.4.2020	30.3.2021	08.8.2021
Date of withholding irrigation	31.12.2019	04.4.2020	11.4.2021	16.8.2021
Date of harvest	28.01.2020	16.4.2020	19.5.2021	25.8.2021

Table 2: Treatment wise fertigation schedule for greengram.

Stage (DAS)	Duration (Days)	Frequency	Quantity (kg fertigation^{-1})								
			75% RDF (kg)			100% RDF (kg)			125% RDF (kg)		
			Urea	MAP	SOP	Urea	MAP	SOP	Urea	MAP	SOP
10	1	1	0.14	2.12	0.13	0.19	2.83	0.17	0.23	3.54	0.22
11-30	20	7	0.07	-	0.04	0.09	-	0.05	0.18	-	0.06
31-45	15	5	0.10	-	0.09	0.13	-	0.12	0.16	-	0.15
46-55	10	3	0.09	-	0.15	0.12	-	0.20	0.15	-	0.25

Table 3: Effect of drip fertigation levels on plant height (cm), DMP (Kg/ha) at harvest, 50 % flowering, LAI peak vegetative stage of greengram.

Treatment	Summer 2020				*Kharif* 2021			
	Plant height @ harvest	DMP @ harvest	50% flowering	LAI	Plant height @ harvest	DMP @ harvest	50% flowering	LAI
T_1	54.6	2404	30.3	2.23	44.1	3076	32.3	2.53
T_2	53.2	2312	31.6	2.03	43.6	2782	31.0	2.47
T_3	55.6	2575	32.0	2.50	45.8	3235	33.6	2.76
T_4	55.3	2428	32.3	2.42	44.4	3096	32.6	2.68
T_5	58.2	3036	35.3	2.73	45.5	3697	35.3	3.03
T_6	58.1	3001	34.6	2.64	45.4	3528	34.0	2.95
T_7	56.9	2989	34.3	2.58	46.4	3427	35.3	2.93
T_8	56.1	2930	35.3	2.56	47.3	3413	34.6	2.85
T_9	58.2	4122	36.6	3.40	51.6	3588	35.6	3.26
T_{10}	57.0	3766	37.6	2.82	53.0	3614	37.0	3.16
T_{11}	60.7	4463	39.3	3.75	57.3	4169	38.3	3.96
T_{12}	58.4	4304	39.6	3.53	54.7	3941	39.3	3.69
T_{13}	47.8	2082	33.3	1.96	41.1	2593	34.0	2.38
SEd	2.2	166	1.6	0.37	1.9	240	1.5	0.32
CD (P=0.05)	4.6	343	3.4	0.76	4.0	497	3.2	0.67

Kumar *et al*., 2020). Similarly, the days to 50% flowering varied from 30.3 to 39.6 and 31.0 to 39.3 days, during summer 2020 and *kharif* 2021 respectively. Among treatments, DF @ 125% RDF, 100% PE with FEP (2 times) (T_{12}) took more days for 50 % flowering (39.6 and 39.3 days during both the years) over all the treatments. Among different levels of drip fertigation practices, DF @ 125% RDF, 100% PE with FFW (2 times) (T_{11}) registered significantly higher LAI of 3.75 during summer 2020; 3.96 during *kharif* 2021 at peak flowering stage.

Different levels of drip fertigation in greengram significantly influenced the Chlorophyll meter reading (SPAD value), crop growth rate, relative growth rate (RGR) between 30 and 45 DAS and 40 DAS and harvest during summer 2020 and *kharif* 2021 (Table 4). Among the treatments, significantly more SPAD values (T_{11}) (43.2 and 45.3 during summer 2020 and 42.8 and 45.9 during *kharif* 2021 at 30 and 45 DAS, respectively) was observed under DF @ 125% RDF, 100% PE with FFW (2 times), similarly same treatment registered higher CGR 14.29 g m^{-2} day^{-1} during summer 2020 and 16.38 g m^{-2} day^{-1} during *kharif* 2021 at 45 DAS- harvest stage. Different levels of drip fertigation in greengram significantly influenced the relative growth rate (RGR) between 40 DAS and harvest during summer 2020 and *kharif* 2021. Among the treatments, significantly higher RGR was measured in treatments T_7 (DF @ 75% RDF, 100% PE with FEP, 2 times) and T_{12} (DF @ 125% RDF, 100% PE with FEP, 2 times) during summer 2020 and T_{10} (DF @ 100% RDF, 100% PE with FEP, 2 times) and T_1 (DF @ 75% RDF, 75% PE with FFW, 2 times) during *kharif* 2021 between 45 DAS and harvest stage, respectively than all other treatments.

The reason for increased CGR, RGR and Chlorophyll meter reading among the treatments could be due to frequent fertigation with water soluble fertilizers which would have provided a well aerated condition at root zone with adequate soil moisture content leading to supply of sufficient concentration of nutrients that did not fluctuate between wet and dry extremes contributes to optimum growth. Similar results were validated with Badr *et al*. (2010).

Effect on yield attributes and yield

The yield attributes *viz*, number of pods per plant, number of seeds per pod, number of seeds per plant, were significantly influenced by the different drip irrigation and fertigation levels are furnished in Table 5. Among treatments, DF @ 125% RDF, 100% PE with FFW (2 times) (T_{11}) produced increased number of pods (35.6 $pant^{-1}$ and 26.9 $pant^{-1}$), number of seeds per pod (7.6 pod^{-1} and 11.4 pod^{-1}) and higher number of grains $plant^{-1}$ of 269 and 308 during summer 2020 and *kharif* 2021) over other treatments tested in the field investigation (Srinivasan *et al*., 2021; Srinivasan *et al*., 2022). There was no significant difference in 100 grain weight (g) due to different drip irrigation and fertigation levels.

It might be due lower soil moisture supply, availability of nutrients also low which leads to low photosynthetic accumulation and results the increased in chaffy grains. These results are in confirmation with the results of Sudhir *et al*. (2011).

The seed and haulm yield were significantly influenced by the treatments imposed in both the years of experimentation (Table 6). Among the drip irrigation and fertigation levels, DF @ 125% RDF, 100% PE with FFW (2 times) (T_{11}) recorded higher seed and haulm yield (1352 kg ha^{-1} and 2512 kg ha^{-1}) during summer 2020 and (1291 kg ha^{-1} and 2403 kg ha^{-1}) during *kharif* 2021, respectively. However, harvest index did not show any significant impact on harvest index of greengram which ranged from 0.31 to 0.36 during summer 2020 and 0.34 to 0.37 during *kharif* 2021. These

Table 4: Effect of drip fertigation levels on SPAD values, crop growth rate (g m^{-2} day^{-1}), relative growth rate (g g^{-1} day^{-1}) of greengram.

Treatment	Summer 2020			*Kharif* 2021		
	SPAD values @ 45 DAS	CGR @ 45 DAS-Harvest	RGR@ 45 DAS-Harvest	SPAD values @ 45 DAS	CGR @ 45 DAS-Harvest	RGR@ 45 DAS-Harvest
T_1	40.5	7.39	0.035	39.2	15.41	0.076
T_2	39.6	7.21	0.036	39.6	13.65	0.072
T_3	42.0	6.43	0.027	42.0	15.93	0.073
T_4	41.5	6.60	0.030	41.5	14.37	0.0679
T_5	43.5	8.50	0.031	43.5	15.75	0.057
T_6	43.3	8.19	0.030	43.3	15.27	0.059
T_7	42.8	7.40	0.027	42.8	15.13	0.063
T_8	42.5	7.52	0.028	42.5	15.52	0.063
T_9	44.5	13.36	0.038	43.3	14.46	0.053
T_{10}	43.5	11.65	0.036	42.9	13.40	0.048
T_{11}	45.3	14.29	0.037	45.9	16.38	0.050
T_{12}	44.2	14.02	0.038	44.2	15.30	0.050
T_{13}	39.0	6.27	0.034	39.0	11.51	0.062
SEd	1.2	1.30	0.002	1.4	1.69	0.004
CD (P=0.05)	2.7	2.69	0.005	2.9	3.49	0.012

results are in line with the findings of Jayakumar *et al.* (2014) and Ajaykumar *et al*. (2022a).

Correlation analysis

The correlation findings were listed in Table 7 of the research. The study's results indicated that, at the 1% level of significance, every variable in the model was positively significant. This indicates that every variable would have an impact on the greengram's grain yield. The correlation coefficients between the grain yield and the plant height (0.97), DMP (0.98), LAI (0.99), number of pods plant^{-1} (0.97), number of seeds pod^{-1} (0.94) and test weight (0.24) revealed that all the attributes were positively related, which strongly suggests that when these variables are increased, the greengram yield will keep increasing Similar results were observed by Ajaykumar *et al.* (2022b).

System productivity

Higher system productivity was observed under the DF @ 125% RDF, 100% PE with FFW (T_{11}) in both 2019-20 and 2021 (23 and 23 kg ha^{-1} day^{-1} respectively) and this was closely followed by DF @ 125% RDF, 100% PE with FEP (T_{12})

Table 5: Effect of drip fertigation levels on yield attributes of greengram during summer 2020 and *Kharif* 2021.

Treatment	Summer 2020				*Kharif* 2021			
	Number of pods plant^{-1}	Number of seeds pod^{-1}	Number of seeds plant^{-1}	100 seed weight (g)	Number of pods plant^{-1}	Number of seeds pod^{-1}	Number of seeds plant^{-1}	100 seed weight (g)
T_1	22.2	6.3	139	3.0	20.1	10.0	202	3.2
T_2	21.2	6.5	138	3.2	20.9	9.4	196	3.2
T_3	24.3	6.7	163	3.2	22.5	9.7	218	3.2
T_4	23.3	6.5	152	3.1	22.2	10.7	238	3.1
T_5	27.5	6.2	168	3.2	20.1	9.8	196	3.0
T_6	26.9	6.8	178	3.0	23.8	10.6	253	3.1
T_7	26.3	6.5	170	3.1	21.4	9.9	213	3.1
T_8	25.4	6.7	169	3.1	22.3	10.4	233	3.1
T_9	30.1	7.0	211	3.2	23.1	10.1	234	3.2
T_{10}	29.0	6.7	191	3.1	23.7	10.2	243	3.0
T_{11}	35.6	7.6	269	3.2	26.9	11.4	308	3.2
T_{12}	35.5	7.2	251	3.2	26.7	10.7	285	3.2
T_{13}	20.0	6.8	138	3.1	17.0	9.0	152	3.1
SEd	2.7	0.3	22	0.08	1.3	0.5	19	0.08
CD (P=0.05)	5.7	0.7	45	NS	2.8	1.1	40	NS

Table 6: Effect of drip fertigation levels on grain yield (kg ha^{-1}), haulm yield (kg ha^{-1}) and harvest index of greengram.

Treatment	Summer 2020			*Kharif* 2021		
	Grain yield	Haulm yield	HI	Grain yield	Haulm yield	HI
T_1	973	2030	0.32	938	1802	0.34
T_2	968	1973	0.33	872	1732	0.34
T_3	1024	2130	0.32	974	1814	0.35
T_4	928	2057	0.31	1001	1887	0.35
T_5	1104	2076	0.35	1071	1890	0.36
T_6	1149	2128	0.35	1098	1991	0.36
T_7	1118	1970	0.36	1046	1955	0.35
T_8	1170	2190	0.35	1057	1982	0.35
T_9	1211	2240	0.35	1158	2056	0.36
T_{10}	1219	2281	0.35	1116	2069	0.35
T_{11}	1352	2512	0.35	1291	2403	0.35
T_{12}	1275	2466	0.34	1284	2194	0.37
T_{13}	858	1787	0.32	811	1596	0.34
SEd	81	176	0.01	62	141	0.02
CD (P=0.05)	168	364	NS	128	290	NS

(22 and 22 kg ha^{-1} day^{-1} respectively). The lowest system productivity was registered with DF @ 75% RDF, 75% PE with FEP (T_2) (15 and 15 kg ha^{-1} day^{-1}) during both the years of study are presented in the Table 8 and 9. The higher system productivity recorded due to higher production of rice and greengram increased the rice equivalent yield that leads to higher system productivity. This is in conformation with the findings of Ramadass and Ramanathan (2017) and Ray *et al.* (2019).

Table 7: Correlation between yield attributes and yield (pooled data analysis).

	Grain yield (kg ha^{-1})	Plant height @ harvest (cm)	DMP @ harvest (kg ha^{-1})	LAI	Number of pods plant^{-1}	Number of seeds plant^{-1}	100 seed weight (g)
Grain yield	1						
Plant height @ harvest	0.97	1					
DMP @ harvest	0.98	0.98	1				
LAI	0.99	0.96	0.98	1			
Number of pods plant^{-1}	0.97	0.97	0.97	0.97	1		
Number of seeds plant^{-1}	0.94	0.94	0.93	0.95	0.98	1	
100 seed weight (g)	0.24	0.31	0.29	0.40	0.36	0.37	1

Table 8: Effect of drip fertigation levels on system productivity (kg ha^{-1} day^{-1}) of aerobic rice-greengram crop.

Treatment	Crop yield (kg ha^{-1})		Rice equivalent yield (kg ha^{-1})		Total grain yield (kg ha^{-1})	System productivity (kg ha^{-1} day^{-1})
	Rabi	Summer				
	Rice	Greengram	*Rabi*	Summer		
T_1	2783	973	2783	2919	5702	16
T_2	2647	968	2647	2904	5551	15
T_3	3101	1024	3101	3072	6173	17
T_4	3098	928	3098	2784	5882	16
T_5	3534	1104	3534	3312	6846	19
T_6	3458	1149	3458	3447	6905	19
T_7	3205	1118	3205	3354	6559	18
T_8	3281	1170	3281	3510	6791	19
T_9	4053	1211	4053	3633	7686	21
T_{10}	3851	1219	3851	3657	7508	21
T_{11}	4504	1352	4504	4056	8560	23
T_{12}	4383	1275	4383	3825	8208	22
T_{13}	3371	858	3371	2574	5945	16

Data not statistically analysed.

Table 9: Effect of drip fertigation levels on system productivity (kg ha^{-1} day^{-1}) of aerobic rice-greengram.

Treatment	Crop yield (kg ha^{-1})		Rice equivalent yield (kg ha^{-1})		Total grain yield (kg ha^{-1})	System productivity (kg ha^{-1} day^{-1})
	Summer	*Kharif*				
	Rice	Greengram	Summer	*Kharif*		
T_1	3042	938	3042	2814	5856	16
T_2	2992	872	2992	2616	5608	15
T_3	3344	974	3344	2922	6266	17
T_4	3213	1001	3213	3003	6216	17
T_5	3482	1071	3482	3213	6695	18
T_6	3494	1098	3494	3294	6788	19
T_7	3318	1046	3318	3138	6456	18
T_8	3357	1057	3357	3171	6528	18
T_9	3850	1158	3850	3474	7324	20
T_{10}	3651	1116	3651	3348	6999	19
T_{11}	4349	1291	4349	3873	8222	23
T_{12}	4070	1284	4070	3852	7922	22
T_{13}	3340	811	3340	2433	5773	16

Data not statistically analysed.

CONCLUSION

Based on the results of both the season, it is concluded that the application of drip fertigation @ 125% RDF, 100% PE with FFW (2 times) (T_{11}) recorded higher growth characters (plant height, dry matter production), physiological parameters like LAI, SPAD values, 50% flowering, CGR, Yield attributes, yield and system productivity were better compared to other treatments. However, it was comparable with the DF @ 125% RDF, 100% PE with FEP (2 times) (T_{12}). Hence, this is considered to be a suitable agro-technique to the greengram growing farmers for realizing better yield and good system productivity.

Conflict of interest: None.

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