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Harsh S Hathi
Department of Vegetable Science, College of Horticulture, S. D. Agricultural University, Jagudan, Mehsana, Gujarat, India

Dr. MV Patel
Associate Professor, Department of Horticulture, C. P. College of Agriculture, S. D. Agricultural University, Dantiwada, Gujarat, India

Shruti B Zankat
Department of Vegetable Science, College of Horticulture, S. D. Agricultural University, Jagudan, Mehsana, Gujarat, India

Corresponding Author:
Harsh S Hathi
Department of Vegetable Science, College of Horticulture, S. D. Agricultural University, Jagudan, Mehsana, Gujarat, India

Effect of liquid organic substances, spray frequency and levels of fertilizer on yield, quality and economics of okra (*Abelmoschus esculentus* (L.) Moench)

Harsh S Hathi, Dr. MV Patel and Shruti B Zankat

Abstract
An investigation was carried out on "Effect of liquid organic substances, spray frequency and levels of fertilizer on okra (*Abelmoschus esculentus* (L.) Moench)" at College Farm, College of Horticulture, S. D. Agricultural University, Jagudan, Gujarat, India during *Kharif*, 2021. The experiment was laid out in Factorial Randomized Block Design with eighteen treatment combinations involving two levels of liquid organic substances *i.e.* o_1 (Panchagavya 3%) and o_2 (Jeevamruta 5%), three levels of spray frequency *i.e.* s_1 (Two spray at 20 & 40 DAS), s_2 (Three spray at 20, 40 & 60 DAS) and s_3 (Four spray at 20, 40, 60 & 80 DAS) and levels of fertilizer in three levels *i.e.* f_1 (100% RDF), f_2 (80% RDF) and f_3 (60% RDF). T_7 (Panchagavya 3% + Four spray at 20, 40, 60 & 80 DAS + 100% RDF) produced superior results on yield and quality parameters *viz*., [number of pickings, number of pods per plants, yield per plant (g), yield per plot (kg) and yield per hectare (t)] and [pod length (cm), pod diameter (mm), crude fiber (%) and crude protein content (%)], respectively and economics as well, as compared to the other treatments.

Keywords: BCR, Jeevamruta, *Kharif*, Panchagavya, RDF

Introduction
Okra is one of the important *kharif* and summer vegetable grown widely in sub-tropical region of the world for its tender pods due to its high adaptability over a wide range of environmental conditions. It is commonly known as lady's finger or Bhindi (*Abelmoschus esculentus* (L.) Moench) belongs to the Malvaceae family (NIHORT, 1986)[10]. The okra plant is erect, herbaceous annual green, stem with radish tinge. Okra is most popular in India, Nigeria, Pakistan, Cameroon, Iraq and Ghana. India ranks first in the area and production of okra in the world. In India, okra covers an area of 521 thousand hectare with the production of 6355 thousand MT with an average productivity of 12.20 MT ha^{-1} (Annon. 2019-20)[5]. In Gujarat, it is grown either as sole or inter crop. The main districts of Gujarat where okra is produced in a bulk are Navsari, Surat and Tapi.

Liquid organic formulations like panchagavya and jeevamruta are the fermented products which are used as plant growth enhancing substances prepared with material derived from plants and animals. They are rich sources of beneficial micro flora which support, stimulate the plant growth and help in getting better vegetative growth and also good quality and yield (Devakumar *et al*. 2011)[6]. These liquid organic substances, when applied to the plants, found to influence metabolic processes of plants such as respiration, photosynthesis, nucleic acid synthesis and ion uptake. They are also rich source of macro and micro nutrients, naturally occurring plant growth promoters like GA_3, cytokinin, NAA *etc.* that are required in different concentrationsforbettergrowthofplant{XuandXu.(2000)[16]andSelvaraj*etal*.(2007)[14]}.

Materials and Methods
A field experiment on okra var. Gujarat Anand Okra 5 (GAO 5) was conducted at College Farm, College of Horticulture, S. D. Agricultural University, Jagudan, Gujarat, India during *kharif* 2021. The experiment was laid out in Factorial Randomized Block Design with total eighteen treatments comprising of three factors *viz*., liquid organic substances (O) *viz*., o_1 (Panchagavya 3%) and o_2 (Jeevamruta 5%); spray frequency (S) *viz*., s_1 (Two spray at 20 & 40 DAS), s_2 (Three spray at 20, 40 & 60 DAS) and s_3 (Four spray at 20, 40, 60 & 80 DAS) and levels of fertilizer *viz*., f_1 (100% RDF), f_2 (80% RDF) and f_3 (60% RDF).

The combination of treatments comprised of Panchagavya 3% + Two spray at 20 & 40 DAS + 100% RDF (T_1), Panchagavya 3% + Two spray at 20 & 40 DAS + 80% RDF (T_2), Panchagavya 3% + Two spray at 20 & 40 DAS + 60% RDF (T_3), Panchagavya 3% + Three spray at 20, 40 & 60 DAS + 100% RDF (T_4), Panchagavya 3% + Three spray at 20, 40 & 60 DAS + 80% RDF (T_5), Panchagavya 3% + Three spray at 20, 40 & 60 DAS + 60% RDF (T_6), Panchagavya 3% + Four spray at 20, 40, 60 & 80 DAS + 100% RDF (T_7), Panchagavya 3% + Four spray at 20, 40, 60 & 80 DAS + 80% RDF (T_8), Panchagavya 3% + Four spray at 20, 40, 60 & 80 DAS + 60% RDF (T_9), Jeevamruta 5% + Two spray at 20 & 40 DAS + 100% RDF (T_{10}), Jeevamruta 5% + Two spray at 20 & 40 DAS + 80% RDF (T_{11}), Jeevamruta 5% + Two spray at 20 & 40 DAS + 60% RDF (T_{12}), Jeevamruta 5% + Three spray at 20, 40 & 60 DAS + 100% RDF (T_{13}), Jeevamruta 5% + Three spray at 20, 40 & 60 DAS + 80% RDF (T_{14}), Jeevamruta 5% + Three spray at 20, 40 & 60 DAS + 60% RDF (T_{15}), Jeevamruta 5% + Four spray at 20, 40, 60 & 80 DAS + 100% RDF (T_{16}), Jeevamruta 5% + Four spray at 20, 40, 60 & 80 DAS + 80% RDF (T_{17}) and Jeevamruta 5% + Four spray at 20, 40, 60 & 80 DAS + 60% RDF (T_{18}) replicated thrice.

The experimental soil was loamy sand, with good drainage condition. As per recommended dose, whole quantity of well decomposed FYM (20 t ha^{-1}) applied to the experiment field before sowing and mixed thoroughly with the soil and dose of N:P:K (100:50:50 kg ha^{-1}) out of which half dose of the nitrogen (N) and full dose of phosphorus (P_2O_5) and potassium (K_2O) were applied as basal dose in the form of urea, single super phosphate (SSP) and muriate of potash (MOP), respectively as per the treatments. The remaining half dose of nitrogen was applied as top dressing in the form of urea at thirty days after sowing. The planting was done at the spacing of 60 cm × 30 cm with gross plot size 3.6 m × 1.8 m and net plot size 2.4 m × 1.2 m. Foliar application of liquid organic substances was performed at 20, 40, 60 and 80 DAS as per the treatments.The total number of pickings were recorded by counting from first picking to the last picking. The number of pods per plant were obtained by summing up the harvested pod numbers at each picking from five tagged plants. The weight of pod was recorded with the help of weighing balance. The yield in terms of plot was noted from individual net plot and its conversion into hectare gave yield per hectare. The length of pod was measured with the help of scale in cm. While, diameter of the same pods was measured by using vernier calipers (Absolute digematic caliper mitu Toyo Co. Japan) at the middle of the finger. The fibre content from green pods was determined by using method given by (Annon. 1960)[4]. Nitrogen content in green pod was estimated by using micro Kjeldahl's method as per the procedure suggested by association of official analytical collaboration (A.O.A.C. 1995)[1] and the protein content (%) in green pod was calculated by multiplying nitrogen content of the green pod (%) with the multiple factor 6.25. Statistical analysis of the data pertaining to yield parameters, quality parameters and economics were analysed as per the methods described by Panse and Sukhatme (1985)[11].

Results and Discussions

Yield paramaters: The mean data on yield attributing characters such as number of pickings, number of pods per plants, yield per plant (g), yield per plot (kg) and yield per hectare (t) are depicted in Table 1.

Number of pickings

Various liquid organic substances, spray frequency and levels of fertilizer were unable to produce significant variation on number of pickings. Maximum number of pickings (11.89), (11.98) and (12.19) were recorded with the application of o_1 (Panchagavya 3%), application of s_3 (Four spray at 20, 40, 60 & 80 DAS) and application off$_1$(100% RDF), respectively.

Number of pods per plant

A perusal of the data reveals that the number of pods per plant was significantly influenced by different liquid organic substances, spray frequency and levels of fertilizer during the period of investigation. Significantly maximum number of pods per plant(10.34), (10.50) and (11.46) were recorded with the treatment o_1 (Panchagavya 3%), treatment s_3 (Four spray at 20, 40, 60 & 80 DAS) and the treatment f_1 (100% RDF), respectively. However, the interaction of all the factors produced non significant variation among them.

The increase in number of pods was might be due to the quantities of IAA and GA present in panchagavya which could have created positive stimuli in the plant system and might have increased the production of growth regulator in the cell system and the action of growth regulators in plant system might have stimulated the necessary growth and development of crop. The present findings were in line with Patel *et al*. (2013)[12] in cowpea.

Yield per plant (g)

An appraisal of the data due to various liquid organic substances, spray frequency and levels of fertilizer treatments were found significant variation for yield per plant (g). The significantly maximum yield per plant (105.17 g) and (119.29 g) was recorded with the treatment o_1 (Panchagavya 3%) and treatment f_1 (100% RDF), respectively. Influence of spray frequency on yield per plant (g) revealed that the significantly maximum yield per plant (107.67 g) was recorded with treatment s_3 (Four spray at 20, 40, 60 & 80 DAS), which remained statistically at par (102.49) with s_2 (Three spray at 20, 40 & 60 DAS). Although, the interaction effect between different liquid organic substances, spray frequency and levels of fertilizer on yield per plant (g) was found non significant.

Increased yield per plant may be due to increase in the plant growth which results in higher metabolic activities in the plants which lead to rapid cell division and cell expansion, higher carbohydrate synthesis and faster loading and mobilization of simple sugars into fruits that ultimately increases yield and yield improving characters. Similar observation was recorded earlier by Ali *et al*. (2011)[2] in green gram-chilli-mustard and Amiry *et al*. (2017)[3] in okra.

Table 1: Effect of liquid organic substances, spray frequency and levels of fertilizer on various yield parameters of okra (*Abelmoschus esculentus* (L.) Moench)

Treatment	Number of pickings		Number of pods per plant		Yield per plant (g)		Yield per plot (kg)		Yield per hectare (t)	
Liquid organic substances (O)										
o_1	11.89		10.34		105.17		2.69		9.34	
o_2	11.37		9.62		97.41		2.42		8.41	
S.Em. ±	0.27		0.18		1.74		0.04		0.15	
C.D. at 5%	NS		0.53		5.01		0.13		0.44	
Spray frequency (S)										
s_1	11.20		9.39		93.71		2.33		8.10	
s_2	11.72		10.06		102.49		2.56		8.90	
s_3	11.98		10.50		107.67		2.77		9.62	
S.Em. ±	0.33		0.22		2.13		0.05		0.19	
C.D. at 5%	NS		0.65		6.14		0.15		0.53	
Levels of fertilizer (F)										
f_1	12.19		11.46		119.29		3.08		10.70	
f_2	11.68		9.90		100.77		2.56		8.90	
f_3	11.03		8.59		83.81		2.02		7.02	
S.Em. ±	0.33		0.22		2.13		0.05		0.19	
C.D. at 5%	NS		0.65		6.14		0.15		0.53	
Interaction effect	**S.Em. ±**	**C.D. at 5%**	**S.Em. ±**	**C.D. at 5%**	**S.Em. ±**	**C.D. at 5%**	**S.Em. ±**	**C.D. at 5%**	**S.Em. ±**	**C.D. at 5%**
O × S	0.46	NS	0.32	NS	3.02	NS	0.08	NS	0.26	NS
O × F	0.46	NS	0.32	NS	3.02	NS	0.08	NS	0.26	NS
S × F	0.57	NS	0.39	NS	3.70	NS	0.09	NS	0.32	NS
O × S × F	0.80	NS	0.55	NS	5.23	NS	0.13	0.38	0.46	1.31
C.V. %	11.90		9.54		8.94		8.88		8.88	

Yield per plot (kg)

Data mentioned in Table 1 revealed that the influence of different liquid organic substances, spray frequency and levels of fertilizer treatments were found significant in terms of yield per plot (kg). The maximum yield per plot (2.69 kg), (2.77 kg) and (3.08 kg) was noted under the treatment o_1 (Panchagavya 3%), treatment s_3 (Four spray at 20, 40, 60 & 80 DAS) and treatment f_1 (100% RDF). Data on interaction effect between liquid organic substances (O), Spray frequency and levels of fertilizer (F) on yield per plot (kg) revealed that there was statistically significant variation. The significantly maximum yield per plot (3.78 kg) was recorded with the treatment combination of $o_1s_3f_1$ and the data are presented in Table 2. However, the interaction of O × S, O × F andS × F were not able to produce significant variation.

Increase in the plot yield might be due to the properties present in panchagavya which can increase the yield by 20 to 25%. Similar observation was recorded earlier by Ali *et al.* (2011)[2] in green gram-chilli-mustard. It also might be due to the hormonal effect of panchagavya sprayed several times which increases the photosynthetic activity of plants and develop better source-sink relation in the crop. Similar results were obtained by Shivran *et al*. (2021)[15] in cabbage.

Table 2: Interaction effect of liquid organic substances, spray frequency and levels of fertilizer on yield per plot (kg) of okra (*Abelmoschus esculentus* (L.) Moench)

Treatment	Yield per plot (kg)					
	o_1			o_2		
	s_1	s_2	s_3	s_1	s_2	s_3
f_1	2.80	3.33	3.78	2.79	2.93	2.86
f_2	2.47	2.69	2.83	2.33	2.38	2.70
f_3	1.96	2.05	2.31	1.65	2.01	2.15
S.Em. ±	0.13					
C.D. at 5%	0.38					
C.V. %	8.88					

Yield per hectare (t)

Examination of the data on influence of different liquid organic substances, spray frequency and levels of fertilizer treatments recorded significant variation on yield per hectare (t). It revealed that the significantly maximum yield per hectare (9.34 t), (9.62 t) and (10.70 t) was recorded with treatment o_1 (Panchagavya 3%), treatment s_3 (Four spray at 20, 40, 60 & 80 DAS) and treatment f_1 (100% RDF). Data on interaction effect between O × S × F on yield per hectare (t) revealed that there was statistically significant variation. The significantly maximum yield per hectare (5.72 t) was recorded with the treatment combination of $o_1s_3f_1$ and the datais depicted in Table 3. Though, the interaction of O × S, O × F andS × F were not able to produce significant variation.

The yield is the manifestation of different growth and yield attributing characters. By application of three sprays of panchagavya alone had better effect. This may be due to the presence of high amount of nutrients, plant growth promoters and different activities of microbes. Foliar spray of panchagavya (3%) resulted in a significant increase in the yield attributes which may be due to the panchagavya constituent coconut water contains kinetin which increases the biomassand yield. By foliar spray of panchagavya all the growth and yield parameters are improved. This might be due

to the faster absorption of nutrients present in panchagavya through cuticle of leaves. Similar observation was recorded earlier by Amiry *et al*. (2017)[3] in okra and Devanda *et al*. (2021)[7] in okra.

Table 3: Interaction effect of liquid organic substances, spray frequency and levels of fertilizer on yield per hectare (t) of okra (*Abelmoschus esculentus* (L.) Moench)

Treatment	Yield per hectare (t)					
	o_1			o_2		
	s_1	s_2	s_3	s_1	s_2	s_3
f_1	9.71	11.56	13.11	9.70	10.18	9.93
f_2	8.58	9.33	9.82	8.08	8.26	9.37
f_3	6.80	7.12	8.03	5.72	6.99	7.46
S.Em. ±	0.46					
C.D. at 5%	1.31					
C.V. %	8.88					

Improvement in yield characters as a result of the application of panchagavya; promotes biological activity in soil and enhance nutrients availability to tomato crop by Gore and Sreenivasa (2011). Presence of naturally occurring, beneficial, effective microorganisms (EMO's) in panchagavya predominantly lactic acid bacteria, yeast, actinomycetes photosynthetic bacteria and certain fungi besides beneficial and proven fertilizers such as *Acetobacter, Azospirillum and Phosphobacterium* were detected which have the beneficial effect especially in improving soil quality, growth and yield of crops. It also contains growth regulatory substances such as IAA, GA, cytokinins and essential plant nutrients (Xu and Xu. 2000[16] and Selvaraj *et al*. 2007[14]). These findings are in conformity with Ramesh *et al*. (2015) [13] in tomato.

Quality parameters

The observations on the different quality parameters such as pod length (cm), pod diameter (mm), crude fibre (%) and crude protein content (%) were recorded and analyzed to evaluate the treatments. Pod length (cm) and pod diameter (mm) produced significant variation whereas crude fibre (%) and crude protein content (%) were unable to produce significant variation. The mean data are depicted in Table 4.

Pod length (cm)

It is explicit from the data that the impact of various liquid organic substances, spray frequency and levels of fertilizer treatments were found significant variation on pod length (cm). Significantly maximum pod length (12 cm) and (12.78 cm) were found with application of o_1 (Panchagavya 3%) and treatment f_1 (100% RDF), respectively. Significantly maximum pod length (12.18 cm) was recorded with treatment s_3 (Four spray at 20, 40, 60 & 80 DAS), which remained statistically at par (11.46 cm) with treatment s_2 (Three spray at 20, 40 & 60 DAS). However, the interaction effect between different liquid organic substances, spray frequency and levels of fertilizer on pod length (cm) was found non significant.

The increase in pod length might be due to the growth promoting effect of panchagavya. The result is in conformity with the findings of Ali *et al*. (2011)[2] in greengram-chilli-mustard.Pod length in okra was increased by foliar spray of panchagavya due to the increased photosynthetic activity, uptake of food nutrients and nitrogen content present in panchagavya. Similar observation was recorded earlier by Amiry *et al*. (2017)[3] in okra, Patel *et al*. (2013)[12] in cowpea and Devanda *et al*. (2021)[7] in okra.

Table 4: Effect of liquid organic substances, spray frequency and levels of fertilizer on various quality parameters of okra (*Abelmoschus esculentus* (L.) Moench)

Treatment	Pod length (cm)		Pod diameter (mm)		Crude fibre(%)		Crude protein content (%)	
Liquid organic substances (O)								
o_1	12.00		15.50		4.54		13.38	
o_2	11.56		14.15		4.63		13.03	
S.Em. ±	0.12		0.09		0.06		0.15	
C.D. at 5%	0.35		0.27		NS		NS	
Spray frequency (S)								
s_1	11.34		13.97		4.66		12.86	
s_2	11.81		14.38		4.60		13.25	
s_3	12.18		14.63		4.48		13.50	
S.Em. ±	0.15		0.11		0.07		0.19	
C.D. at 5%	0.42		0.33		NS		NS	
Levels of fertilizer (F)								
f_1	12.78		15.14		4.45		13.54	
f_2	11.72		14.30		4.59		13.19	
f_3	10.83		13.53		4.70		12.87	
S.Em. ±	0.15		0.11		0.07		0.19	
C.D. at 5%	0.42		0.33		NS		NS	
Interaction effect	**S.Em. ±**	**C.D. at 5%**	**S.Em. ±**	**C.D. at 5%**	**S.Em. ±**	**C.D. at5%**	**S.Em. ±**	**C.D. at 5%**
O × S	0.21	NS	0.16	NS	0.10	NS	0.27	NS
O × F	0.21	NS	0.16	NS	0.10	NS	0.27	NS
S × F	0.25	NS	0.20	NS	0.12	NS	0.33	NS
O × S × F	0.36	NS	0.28	NS	0.17	NS	0.46	NS
C.V. %	5.30		3.37		6.60		6.05	

Pod diameter (mm)

Examination of the data on influence of different liquid organic substances, spray frequency and levels of fertilizer treatments were able to produce significant variation on pod diameter (mm). The application of o_1 (Panchagavya 3%) and treatment f_1 (100% RDF) gave significantly maximum pod diameter (15.10 mm) and (15.14 mm), respectively. Significantly maximum pod diameter (14.63 mm) was

recorded with treatment s_3 (Four spray at 20, 40, 60 & 80 DAS), which remained statistically at par (14.38 mm) with treatment s_2 (Three spray at 20, 40 & 60 DAS). Although, the interaction effect between various liquid organic substances, spray frequency and levels of fertilizer on pod diameter (mm) was unable to produce significant variation.

The increase in pod diameter might be attributed to the increased availability of NPK and water at the critical stages of the crop growth resulting in early establishment, vigorous growth and development of plants leading to the longer and wider fruits. These results are in conformity with the findings of Amiry *et al*. (2017)[3] in okra and Shivran *et al*. (2021)[15] in cabbage.

Crude fibre (%)

Different liquid organic substances, spray frequency and levels of fertilizer were produced non significant variation on crude fibre (%). The application of o_1 (Panchagavya 3%), application of s_3 (Four spray at 20, 40, 60 & 80 DAS) and application of f_1 (100% RDF), respectively produced minimum crude fibre (%) *i.e.* (4.54%), (4.48%) and (4.45%).

Crude protein content (%)

Various liquid organic substances, spray frequency and levels of fertilizer were unable to produce significant variation on crude protein content (%). The maximum crude protein content (%) (13.38%), (13.50%) and (13.54%) were registered with the treatment o_1 (Panchagavya 3%), treatment s_3 (Four spray at 20, 40, 60 & 80 DAS) and treatment f_1 (100% RDF), respectively.

Economics

The data of total cost (₹/ha), gross returns (₹/ha) and net returns (₹/ha) is plotted in the Figure 1. While the data of BCR is plotted in Figure 2.

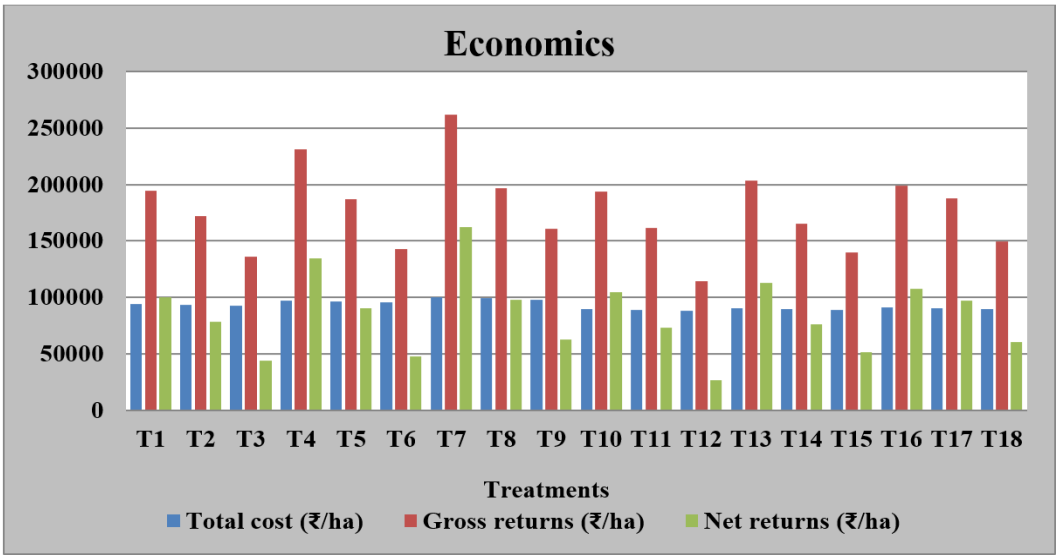

Fig 1: Effect of liquid organic substances, spray frequency and levels of fertilizer on total cost (₹/ha), gross returns (₹/ha) and net returns (₹/ha) of okra (*Abelmoschus esculentus* (L.) Moench)

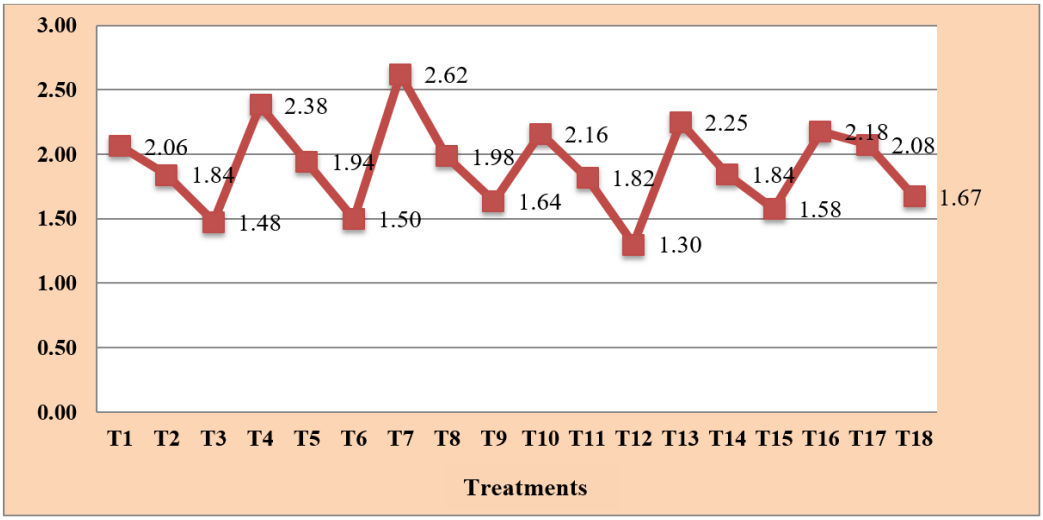

Fig 2: Effect of liquid organic substances, spray frequency and levels of fertilizer on BCR of okra (*Abelmoschus esculentus* (L.) Moench)

The details of economics *i.e*. gross return, cost of cultivation, net return and BCR on data basis for different treatments have been calculated and presented in Table 5. It apparents from Table 5 that the treatment T_7 (combination of $o_1s_3f_1$) noted maximum gross return of ₹2,62,200 per hectare, net return of ₹1,62,170 per hectare and BCR of 2.62. These results are in close conformity with findings of Kondapa *et al*. (2009)[9] in chilli and Gopakkali and Sharanappa (2014)[8] in chilli.

Table 5: Effect of liquid organic substances, spray frequency and levels of fertilizer on economics of okra (*Abelmoschus esculentus* (L.) Moench)

Treatment number	Treatment combination	Total cost (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	BCR
T_1	$o_1s_1f_1$	94170	194200	100030	2.06
T_2	$o_1s_1f_2$	93175	171600	78425	1.84
T_3	$o_1s_1f_3$	92168	136000	43832	1.48
T_4	$o_1s_2f_1$	97100	231200	134100	2.38
T_5	$o_1s_2f_2$	96105	186600	90495	1.94
T_6	$o_1s_2f_3$	95098	142400	47302	1.50
T_7	$o_1s_3f_1$	100030	262200	162170	2.62
T_8	$o_1s_3f_2$	99035	196400	97365	1.98
T_9	$o_1s_3f_3$	98028	160600	62572	1.64
T_{10}	$o_2s_1f_1$	89795	194000	104205	2.16
T_{11}	$o_2s_1f_2$	88800	161600	72800	1.82
T_{12}	$o_2s_1f_3$	87793	114400	26607	1.30
T_{13}	$o_2s_2f_1$	90538	203600	113062	2.25
T_{14}	$o_2s_2f_2$	89542	165200	75658	1.84
T_{15}	$o_2s_2f_3$	88535	139800	51265	1.58
T_{16}	$o_2s_3f_1$	91280	198600	107320	2.18
T_{17}	$o_2s_3f_2$	90285	187400	97115	2.08
T_{18}	$o_2s_3f_3$	89278	149200	59922	1.67

Conclusions

On the basis of results obtained from the present investigation, it can be concluded that the foliar spray of 3% panchagavya at 20, 40, 60 & 80 DAS in okra along with 100% RDF is the best in terms of yield and quality parameters and in economics as well.

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