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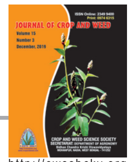

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Effect of nutrient sources on quality attributes of brinjal-fenugreek cropping sequence

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ABSTRACT

A field experiment was conducted at experimental Farm, Division of Vegetable Science, SKUAST-Kashmir during two consecutive years of 2016 and 2017. The experiment comprised of thirteen treatments which was laid out in Randomized Complete Block Design with three replications. The objective of this research was to determine the influence of nutrient sources on quality attributes in a brinjal-fenugreek cropping sequence. Observations for quality attributes were recorded for both the main crop-brinjal as well as the succeeding crop- fenugreek. The treatment T_6 (7.5t FYM+ 1.5t VC+ 1.5t PM+ 5t SM + 4t DW ha^{-1}) outperformed all other treatments except T_9 under study in terms of enhancing quality features in both the main crop and succeeding crop. After threadbare discussion of the study it was observed that the treatment T_9 (50% RFD + 50% PM) recorded a maximum nitrogen, phosphorus, potassium and protein content for the main crop which proved to be significantly superior to all other treatments. It was further observed that treatment T_{12} receiving the nutrients through chemical fertilizers only recorded poor performance in terms of quality parameters of both the main crop and succeeding crop.

Keywords: Brinjal, cropping sequence, fenugreek, inorganic fertilizers, organic manures and quality

India is known as a horticulture paradise (Saravaiya and Patel, 2005), as it produces a wide variety of vegetables. Brinjal is the second most important vegetable crop after tomato. It's also known as eggplant, and it's a major vegetable crop that originated in India(Kiran *et al*., 2010). Brinjal is a highly nutritious vegetable that is high in vitamins A and C as well as minerals such as calcium, magnesium and phosphorus. It also has therapeutic benefits (Rajan and Markose, 2002). Diabetes, asthama, cholera, bronchitis and diarrhoea are among the medical applications of eggplant. Its fruit and leaves have also been shown to reduce blood cholesterol levels. Fenugreek leaves as well as stems are rich in calcium, iron, carotene and ascorbic acid. Fenugreek stimulates digestive process as well as metabolism. Seeds are rich in essential amino acids and trigonelline for which fenugreek is so well known for medicinal uses. Seeds contain steroid "diosgenin" which is used in the preparation of contraceptives (Saini, 2005). Nutrient management is important for cropping system productivity, and nutrient management on a system level, rather than per crop, leads to improved efficiency and economics, as well as system sustainability (Hegde and Babu, 2002). Inclusion of legume crops within a cropping system, regularly or intermittently, is of great help owing to their soil-ameliorating benefits.In addition, a significant amount of nutrients is left for the succeeding crop (Stagnari *et al*., 2017). Furthermore, it is a well- known fact that nutrient demand is essentially a genetic trait of crop plants, and it varies from crop to crop. Plants require large amounts of essential plant nutrients such as nitrogen, phosphorus and potassium. If one of the three components are short in supply, there will be the limited growth and yield of crop. Hence, a balanced proportion of nutrient management means the supply of all the essential nutrients to the crop to improve growth and development. However, it has been observed that with indiscriminate application of chemical fertilizers, the soil health became deteriorated, the number of beneficial microbes has been greatly impacted thereby reducing the nutrient uptake and adversely affecting the quality of vegetables (Agarwal, 2003). Even a well-balanced application of inorganic fertilizers is insufficient to maintain a good soil health condition. In addition, it became very challenging for marginal farmers to purchase chemical fertilizers at exorbitant prices in developing countries like India.This necessitates the application of organic sources which are slow releasing fertilizers to ensure increased crop productivity and also prevent soil from degradation, thereby ensuring sustainable vegetable production (Singh, 2006). Therefore, an effort was made to study the effects of nutrient management on the quality of the brinjal-fenugreek planting system in the Kashmir Valley.

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MATERIALS AND METHODS

The field trial was conducted for two consecutive years of 2016 and 2017 at experimental location of Vegetable Science Division, Sher-e-Kashmir University of Agricultural Sciences and Technology, Shalimar, Kashmir. The experimental field site lies at 34.1° North latitude and 74.89° East longitude and an altitude of 1587 meters above mean sea level. The experimental site has temperate climate and the valley is frequently covered with snow during the winter months. The soil texture is clay loam, neutral in soil reaction, low in nitrogen and medium in phosphorus and potassium content. The trial was carried out in Randomized Complete Block Design with three replications over two years without changing site of the experiment. The experiment comprised of thirteen treatments viz., T_1 (FYM @ 38 t ha^{-1}), T_2 (VC @ 8 t ha^{-1}), T_3 (PM @ 8 t ha^{-1}), T_4 (SM @ 25 t ha^{-1}), T_5 (DW @ 20 t ha^{-1}), T_6 (7.5 t FYM+ 1.5t VC+ 1.5 t PM+ 5 t SM + 4 t DW ha^{-1}), T_7 (50% RFD + 50% FYM), T_8 (50% RFD + 50% VC), T_9 (50% RFD + 50% PM), T_{10} (50% RFD + 50% SM), T_{11} (50% RFD + 50% DW), T_{12} (RFD) and T_{13} (Control). The brinjal was taken as main crop and all the nutrients, organic as well inorganic were applied to it. The fenugreek was grown as a succeeding crop to investigate the fertilizer carryover impact. The well decomposed farm yard manure (FYM), vermicompost (VC), poultry manure (PM), sheep manure (SM) and dal weed (DW) were applied and integrated in soil two weeks before sowing according to treatments either alone or in combination with other organic as well as inorganic fertilizers. Brinjal was transplanted at a spacing of 60 x 45 cm during *kharif* seasons of 2016 and 2017. The seeds of succeeding crop fenugreek were sown in rows 30 cm apart during *rabi* 2016 and 2017. Other crop management practices were followed as per recommendation of the region. For two consecutive years, quality parameters of the main crop -brinjal and the succeeding crop-fenugreek were observed. The statistical analysis was conducted using the F-test, as recommended by Gomez and Gomez (1984).

For dry matter content, one hundred gram sample (fresh fruits for main crop and fresh leaves in case of succeeding crop) from each treatment was chopped into small pieces and dried in the sun before being oven dried at 60°C until the weight remained constant. The dried material was weighed and the dry matter content in percent was calculated. The TSS of fresh fruits was determined using a refractometer. The concentration of vitamin C in the samples was determined using the 2, 6-dichlorophenol indophenol visual titration method (A.O.A.C., 1975) and expressed in mg 100 g^{-1} of fresh weight. Fresh fruit anthocyanin concentration was determined using Thimmaiah's (2006) method and expressed in mg 100g^{-1} of fresh weight. Kjeldhal's method was used to calculate the protein content of each treatment by determining the percentage of N (Tandon, 1993). To determine the protein content in fresh fruits for the main crop and fresh leaves for the succeeding crop, the per cent N was multiplied by 6.25 and expressed in per cent. For the nutrient analysis, fruits from 10 randomly selected observational plants were harvested at the final harvesting stage. Kjeldhal's method was used to determine the nitrogen content in brinjal fruits (Tandon ,1993). The Vanadate molybadate method was used to determine the amount of phosphorus in brinjal fruits (Tandon,1993). A flame photometer was used to assess potassium in brinjal fruits (Piper ,1966).

RESULTS AND DISCUSSION

Dry matter and TSS content of brinjal

Experimental data pertaining to dry matter content and TSS content of brinjal showed significant difference among the treatments under study (Table 1).The treatment T_6 showed significantly higher values for dry matter (9.91 %) and TSS content (6.75 °brix). The favourable influence of organic manures on soil characteristics and biological qualities, as well as their ability to solubilize available plant nutrients, could explain the rise in dry matter content. Total soluble solids (TSS) content was directly influenced by dry matter. As a result of the increase in dry matter, the TSS content of the fruit increased as reported by Narayan *et al*. (2013) and Sheikh *et al*. (2017).

Vitamin C and Anthocyanin content of brinjal

After perusal of the data presented in Table 2 it was noted that treatment T_6recorded highest vitamin C and anthocyanin content among all the treatments under study during *kharif* 2016 and 2017, and was shown to be considerably superior to all other sole as well as combined applications. Regarding pooled analysis the same trend was also found in T_6 which recorded significantly maximum amount of vitamin C (18.03 mg 100 g^{-1}) and anthocyanin (0.73 mg 100 g^{-1}) content over all other treatments.The rise in vitamin C level could be attributable to growth-promoting chemicals that expedited carbohydrate synthesis, resulting in an increase in vitamin C content. Increased intake of nitrogen, which may have contributed to a higher rate of carbohydrate synthesis and translocation to fruit (Sable *et al*., 2007), could explain the rise in vitamin C due to the integration of organic sources. Organic manure integration boosted nutrient mobilization and uptake, which may have benefited plant metabolism and resulted in an increase in anthocyanin content.

Table 1: Effect of nutrient management on dry matter(%) and TSS (°Brix) content of brinjal

	Treatment combinations	Dry matter (%)			TSS (⁰ Brix)		
		Kharif 2016	*Kharif* 2017	Pooled data	*Kharif* 2016	*Kharif* 2017	Pooled data
T_1	Farmyard manure	8.83	8.90	8.86	6.40	6.32	6.36
T_2	Vermicompost (VC)	9.30	9.50	9.40	7.00	6.05	6.52
T_3	Poultry manure (PM)	9.50	9.70	9.59	6.73	6.65	6.69
T_4	Sheep manure (SM)	8.40	8.59	8.50	5.92	5.00	5.46
T_5	Dal weed (DW)	7.91	8.09	8.00	5.49	5.38	5.44
T_6	Integration (all organic manures)	9.79	10.03	9.91	6.81	6.70	6.75
T_7	50%RFD+50%FYM	8.38	8.70	8.54	6.10	5.99	6.04
T_8	50%RFD+50%VC	8.80	9.00	8.90	6.50	6.41	6.45
T_9	50%RFD+50%PM	9.02	9.20	9.11	6.55	6.42	6.48
T_{10}	50%RFD+50%SM	8.16	8.40	8.28	5.71	4.72	5.21
T_{11}	50%RFD+50%DW	7.80	8.00	7.90	5.70	4.84	5.27
T_{12}	RFD	8.68	8.89	8.79	6.32	6.21	6.26
T_{13}	Control	7.60	7.80	7.69	4.90	4.01	4.45
	LSD (0.05)	**0.22**	**0.14**	**0.12**	**0.10**	**0.28**	**0.15**
	SEm(±)	**0.07**	**0.05**	**0.04**	**0.03**	**0.09**	**0.05**

Table2: Effect of nutrient management on vitamin C (mg100g^{-1}) and anthocyanin content (mg 100 g^{-1}) of brinjal

	Treatment combinations	Vitamin C (mg 100g^{-1})			Anthocyanin (mg 100 g^{-1})		
		Kharif 2016	*Kharif* 2017	Pooled data	*Kharif* 2016	*Kharif* 2017	Pooled data
T_1	Farmyard manure	15.50	15.99	15.74	0.57	0.58	0.58
T_2	Vermicompost(VC)	17.11	17.23	17.17	0.67	0.69	0.68
T_3	Poultry manure (PM)	17.50	17.59	17.55	0.68	0.72	0.70
T_4	Sheep manure(SM)	15.90	15.40	15.65	0.49	0.52	0.51
T_5	Dal weed (DW)	13.61	14.23	13.92	0.48	0.50	0.49
T_6	Integration(all organic manures)	17.80	18.26	18.03	0.72	0.74	0.73
T_7	50%RFD+50%FYM	14.70	15.07	14.89	0.59	0.61	0.60
T_8	50%RFD+50%VC	16.51	17.21	16.86	0.61	0.63	0.62
T_9	50%RFD+50%PM	16.70	17.23	16.96	0.65	0.66	0.66
T_{10}	50%RFD+50%SM	14.21	14.72	14.46	0.46	0.49	0.48
T_{11}	50%RFD+50%DW	13.01	13.55	13.28	0.44	0.46	0.45
T_{12}	RFD	16.02	16.50	16.26	0.53	0.54	0.53
T_{13}	Control	12.21	12.03	12.12	0.39	0.39	0.39
	LSD (0.05)	**0.21**	**0.45**	**0.24**	**0.32**	**0.32**	**0.20**
	SEm(±)	**0.07**	**0.15**	**0.08**	**0.11**	**0.11**	**0.06**

Tables 3 and 4 show that during *kharif* 2016 and 2017, treatment T_9 (50 per cent RFD + 50 per cent PM) recorded the highest nitrogen, phosphorus, potassium, and protein content among the 13 treatments studied. Treatment T_9, which recorded a nitrogen concentration of 0.39 per cent, a phosphorus content of 0.063 per cent, a potassium content of 0.35 per cent, and a protein content of 2.44 per cent, was significantly superior to all other treatments under study.The higher nutrient (N, P, and K) content in the fruit resulting from the combined use of organic and inorganic sources could be attributed to the crop's balanced nitrogen availability throughout the growth season. Conjunctive (integrated) application of organics with inorganic sources of nutrients reduced reliance on chemical inputs and provided not just macro but also micro nutrients, which improved the soil physico- chemical properties and boosted the efficiency of applied nutrients as reported by Parihar *et al*. (2010) and Nisar *et al*. (2019). Increasing N content in fruit is closely related with increased protein content in fruit, therefore, integrated nutrient management resulted in higher protein content in fruit (Choudhary *et al*., 2011).

Table 3: Effect of nutrient management on nitrogen content (%) and phosphorus content (%) of brinjal fruit

	Treatment combinations	Nitrogen content (%)			Phosphorus content (%)		
		***Kharif* 2016**	***Kharif* 2017**	**Pooled data**	***Kharif* 2016**	***Kharif* 2017**	**Pooled data**
T_1	Farmyard manure	0.24	0.30	0.27	0.041	0.043	0.042
T_2	Vermicompost (VC)	0.28	0.32	0.30	0.045	0.048	0.047
T_3	Poultry manure (PM)	0.30	0.33	0.31	0.047	0.050	0.049
T_4	Sheep manure(SM)	0.23	0.28	0.25	0.037	0.038	0.037
T_5	Dal weed (DW)	0.23	0.25	0.24	0.033	0.035	0.034
T_6	Integration(all organic manures)	0.31	0.33	0.32	0.053	0.053	0.053
T_7	50%RFD+50%FYM	0.35	0.37	0.36	0.056	0.060	0.058
T_8	50%RFD+50%VC	0.36	0.38	0.37	0.059	0.063	0.061
T_9	50%RFD+50%PM	0.38	0.40	0.39	0.061	0.065	0.063
T_{10}	50%RFD+50%SM	0.27	0.31	0.29	0.043	0.046	0.044
T_{11}	50%RFD+50%DW	0.25	0.29	0.27	0.038	0.040	0.039
T_{12}	RFD	0.32	0.36	0.34	0.053	0.058	0.056
T_{13}	Control	0.15	0.12	0.13	0.022	0.018	0.020
	LSD (0.05)	**0.024**	**0.022**	**0.016**	**0.004**	**0.003**	**0.002**
	SEm(±)	**0.008**	**0.007**	**0.005**	**0.001**	**0.001**	**0.001**

Table 4:Effect of nutrient management on potassium content (%) and protein content (%) of brinjal fruit

	Treatment combinations	Potassium content (%)			Protein content (%)		
		***Kharif* 2016**	***Kharif* 2017**	**Pooled data**	***Kharif* 2016**	***Kharif* 2017**	**Pooled data**
T_1	Farmyard manure	0.21	0.22	0.21	1.50	1.87	1.68
T_2	Vermicompost (VC)	0.24	0.25	0.25	1.75	2.02	1.88
T_3	Poultry manure (PM)	0.26	0.27	0.26	1.87	2.06	1.96
T_4	Sheep manure(SM)	0.19	0.19	0.19	1.45	1.66	1.55
T_5	Dal weed (DW)	0.17	0.18	0.17	1.43	1.60	1.51
T_6	Integration(all organic manures)	0.28	0.29	0.28	1.93	2.10	2.01
T_7	50%RFD+50%FYM	0.31	0.32	0.31	2.18	2.30	2.24
T_8	50%RFD+50%VC	0.33	0.33	0.33	2.24	2.39	2.31
T_9	50%RFD+50%PM	0.34	0.36	0.35	2.37	2.52	2.44
T_{10}	50%RFD+50%SM	0.23	0.24	0.23	1.68	1.93	1.80
T_{11}	50%RFD+50%DW	0.20	0.21	0.20	1.55	1.80	1.68
T_{12}	RFD	0.30	0.31	0.30	2.04	2.24	2.14
T_{13}	Control	0.13	0.16	0.14	0.93	0.76	0.84
	LSD (0.05)	**0.023**	**0.021**	**0.015**	**0.29**	**0.14**	**0.16**
	SEm(±)	**0.008**	**0.007**	**0.005**	**0.10**	**0.04**	**0.05**

Quality parameters of fenugreek

Data pertaining to dry matter, chlorophyll content, vitamin C, and protein content of succeeding crop fenugreek, presented in Tables 5 and 6 revealed significant variation due to various treatments. Treatment T_6 recorded maximum dry matter content of 13.74 percent, a chlorophyll content of 15.42 mg 100 g^{-1}, a vitamin C content of 64.63 mg 100 g^{-1}, and a protein content of 6.49 per cent, all of which were significantly superior to other treatments studied, while the treatment T_{13} recorded the minimum values for the above mentioned parameters. The slow release properties of organic manures made nutrients both macro and micro available throughout the crop growth, resulting in an enhancement in the above mentioned qualitative features in the crop. The addition of organic matter also improved the physical and biological qualities of the soil. Furthermore, organic manures are thought to be a repository for beneficial microbes. These microbes are important because they can fix nitrogen, cycle nutrients, mobilise nutrients and improve phosphorus uptake. They also produce bioactive compounds such as vitamins, enzymes, hormones as well as antifungal and antibacterial substances, all of which promote plant development and increase quality as reported by Kamlakannan and Manivannan (2003) and Sharma *et al*. (2008).

Table 5: Effect of nutrient management on chlorophyll (mg 100g^{-1}) and dry matter content (%) of succeeding crop fenugreek

	Treatment combinations	Chlorophyll (mg 100g^{-1})			Dry matter content (%)		
		Rabi 2016	*Rabi* 2017	Pooled data	*Rabi* 2016	*Rabi* 2017	Pooled data
T_1	Farmyard manure	13.66	14.10	13.88	12.46	13.11	12.79
T_2	Vermicompost (VC)	14.00	14.45	14.22	12.76	13.29	13.03
T_3	Poultry manure (PM)	14.46	14.89	14.68	12.96	13.44	13.20
T_4	Sheep manure(SM)	13.20	13.65	13.42	12.16	12.72	12.44
T_5	Dal weed (DW)	12.90	13.45	13.17	11.96	12.53	12.25
T_6	Integration(all organic manures)	15.20	15.64	15.42	13.46	14.02	13.74
T_7	50%RFD+50%FYM	11.76	11.35	11.55	9.50	9.99	9.74
T_8	50%RFD+50%VC	12.11	12.64	12.38	9.80	10.26	10.03
T_9	50%RFD+50%PM	12.71	12.26	12.48	10.16	10.65	10.40
T_{10}	50%RFD+50%SM	11.49	11.94	11.72	9.16	9.75	9.45
T_{11}	50%RFD+50%DW	11.01	11.45	11.23	8.66	9.26	8.96
T_{12}	RFD	10.10	10.65	10.37	7.86	8.28	8.07
T_{13}	Control	9.50	9.98	9.74	6.20	6.86	6.53
	LSD (0.05)	**0.54**	**0.28**	**0.29**	**0.50**	**0.50**	**0.34**
	SEm(±)	**0.18**	**0.09**	**0.10**	**0.17**	**0.17**	**0.11**

Table 6: Effect of nutrient management on Vitamin C (mg 100g^{-1}) and protein content (%) of succeeding crop fenugreek

	Treatment combinations	Vitamin C (mg 100g^{-1})			Protein content (%)		
		Rabi 2016	*Rabi* 2017	Pooled data	*Rabi* 2016	*Rabi* 2017	Pooled data
T_1	Farmyard manure	58.80	59.03	58.91	6.10	6.26	6.18
T_2	Vermicompost (VC)	60.93	61.03	60.98	6.20	6.33	6.26
T_3	Poultry manure (PM)	62.60	62.96	62.78	6.22	6.45	6.34
T_4	Sheep manure (SM)	57.19	57.61	57.40	5.63	5.78	5.71
T_5	Dal weed (DW)	55.38	56.10	55.74	5.52	5.70	5.61
T_6	Integration (all organic manures)	64.38	64.88	64.63	6.41	6.57	6.49
T_7	50%RFD+50%FYM	51.05	51.86	51.45	5.37	5.49	5.43
T_8	50%RFD+50%VC	52.74	53.08	52.91	5.53	6.06	5.79
T_9	50%RFD+50%PM	53.93	54.51	54.22	5.95	6.33	6.14
T_{10}	50%RFD+50%SM	50.76	51.25	51.00	5.12	5.33	5.22
T_{11}	50%RFD+50%DW	50.10	50.83	50.46	5.04	5.16	5.10
T_{12}	RFD	50.08	50.23	50.15	5.29	5.35	5.32
T_{13}	Control	47.25	45.81	46.53	4.76	4.27	4.51
	LSD (0.05)	**0.47**	**0.70**	**0.51**	**0.17**	**0.16**	**0.11**
	SEm(±)	**0.16**	**0.13**	**0.17**	**0.06**	**0.05**	**0.04**

CONCLUSION

It may be concluded that brinjal-fenugreek cropping system performed well under Kashmir conditions. Among treatments under study, treatment T_6 (integration of all organic manures) was found to be the best treatment as compared to the other treatments in terms of improving the quality attributes of main crop brinjal as well as the succeeding crop fenugreek.When compared to the use of inorganic fertilizers, all types of organic manures were found to be beneficial in boosting crop quality. The incorporation of all organic manures, on the other hand, resulted in the highest quality brinjal fruits in terms of dry matter, TSS, vitamin C and anthocyanin. Furthermore, organic manures have a residual effect on the succeeding crop, and the quality of the succeeding crop fenugreek was observed to be improved in terms of increased chlorophyll, dry matter, vitamin C, and protein content when compared to inorganic fertilizers, which have the least residual effect. As a result of the findings, it can be concluded that integration of organic manures is more fruitful and it can be used to harness a sustainable and high-quality

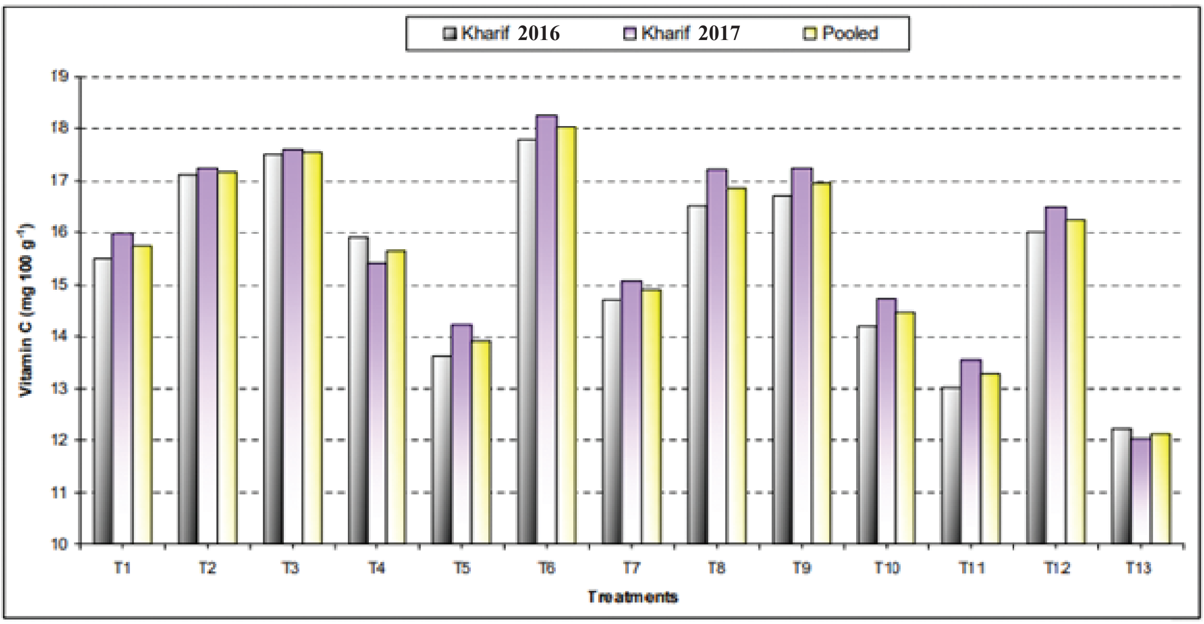

Fig. 1 : Effect of nutrient management on vitamin C (mg 100g^{-1}) of brinjal

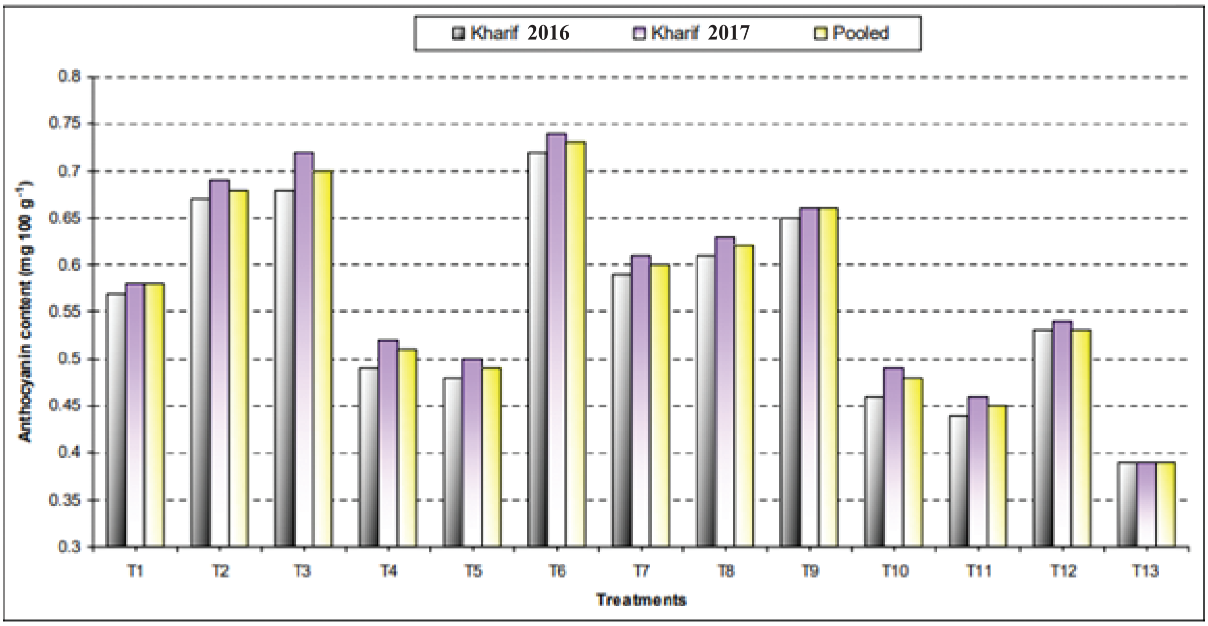

Fig. 2: Effect of nutrient management on anthocyanin content (mg 100 g-1) of brinjal

yield in the brinjal-fenugreek cropping sequence, with the added benefit of fertilizer economy in the succeeding crop.

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