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Carry over effect of organic manures and inorganic fertilizers on growth, yield and quality of residual crop fenugreek in brinjal-fenugreek cropping sequence

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Abstract
Experiment was conducted during kharief and rabi season of 2012-13 to 2013-14 at experimental field of division of vegetable science SKUAST-K Shalimar. Immediately after harvest of brinjal, fenugreek was grown as residual crop. At the inception of experiment, the soil was clay loam in texture, near to neutral in reaction and having low status of available N, medium K and high P. The experiment consisted of thirteen treatment combinations of integrated nutrient management practices for application of recommended dose of nutrients through different sources, viz. organic manures (FYM, poultry manure, vermicompost, sheep manure, dal weed) and inorganic fertilizers (N, P & K), applied alone or in various combinations. In residual crop fenugreek, the growth attributes viz. plant height, branches plant^{-1} and yield hectare^{-1} were best in substitution of 50% of recommended dose of NPK through poultry manure and was followed by the treatment were 50% of recommended dose of NPK was substituted through vermicompost. The same treatment also resulted in minimum days to harvest the crop and was lowest as compared to all other treatment combinations, indicating the higher availability of residual nutrients in the said treatment. The quality parameters viz. vitamin C content, protein content, dry matter and total chlorophyll were recorded highest in the organic treatment T_6 receiving the recommended nutrients through integration of all manures like farm yard manure, poultry manure, vermicompost, sheep manure and dal weed and was followed by the treatment T_3 receiving the recommended nutrients through poultry manure only. Treatment T_{12} receiving the nutrients through chemical fertilizers only recorded poor performance in terms of growth as well as quality parameters of the crop. This shows that the chemical fertilizers provide least residual effect.

Keywords: Brinjal, cropping sequence, carry-over effect of manures, fenugreek, growth, integrated nutrient management, quality, residual effect, and yield parameters

Introduction
Nutrient requirement is basically a genetic characteristic of the crop plants and its requirement may vary from crop to crop. The major plant nutrients like nitrogen, phosphorus and potassium are required by the plants in high quantities. Growth and yield gets restricted if any of the three elements are in short supply. So, balanced nutrition demands supply of all the essential nutrients. The imbalanced and excessive use of chemical fertilizers in the crops has made the soils sick and the population of beneficial microorganisms also gets highly effected. Even the balanced application of inorganic fertilizer does not sustain the soil because of leaching losses. This necessitates the exploitation of organic sources. These organic fertilizers are slow releasing in nature and can help in overcoming the leaching losses. But at the same time these organic manures does not meet the nutrient demands of the crop during the initial phase of crop growth because of their slow release. So, there is a need to develop a sustainable production system which can meet the nutrient demands of the crop and at the same time can take care of the soil as well. In this context, integrated use of chemical fertilizers and organic manures assume greater importance. In integrated system the immediate nutrient demands are met by inorganic fertilizers and manures provide the nutrients on long term basis. The physical as well as biological condition of soil is improved and leaching losses are reduced substantially. Also the increasing pressure on chemical fertilizer is reduced considerably due to integrated systems.

Conventionally fertilizer application was based on the nutrient management of individual crop and the carry over effect of manures and fertilizers applied to the preceding crop was generally ignored. Nutrient management on system basis, rather than to individual crop, leads to higher efficiency and economics besides system sustainability. Also, the inclusion of legume crops within a cropping system, regularly or intermittently, is of great help because of their soil-

ameliorating benefits. It has been observed that nitrogen fixed by the legume crops not only meet their own nitrogen requirements but also a sizable quantity is left for the succeeding crop (Prasad, 1996) [13]. The soil organic carbon, available nitrogen, phosphorus and potassium contents of the soil increases through legume based rotation as compared to non-legume (Dwivedi *et al*., 2003) [3]. Keeping in view the importance of organic manures and their residual effect, an experiment was designed to assess the direct as well as carry-over effect of organic manures and inorganic fertilizers on brinjal (*Solanum melongena* L.)- fenugreek (*Trigonella foenum graecum* L.) cropping sequence.

Material and Methods

Field experiment on brinjal-fenugreek cropping system was carried out at Experimental Field of the Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar. The experimental field (site) is situated at 34.1° North latitude and 74.89° East longitude with an altitude of 1587 meters above mean sea level. The climate of the experimental site is temperate type with moderately hot summers and very cold winters. The valley mostly remains covered with snow during the winter months. The average annual precipitation is 816.3 mm (average of past 30 years) most of which is received in the form of snow and rains from December to April. The soil is clay loam in texture, neutral in soil reaction, low in nitrogen and medium in phosphorus and potassium. The initial soil test values of the experimental field are presented in Table-1. Nutrient contents of the organic manure used in the experiment are shown in Table-2

Table 1: Initial nutrient status of the experimental field.

Chemical characteristics	Value
pH	7.10
Organic carbon (%)	2.34
Electrical conductivity (d Sm^{-1})	0.147
Available N (kg ha^{-1})	290.50
Available P (kg ha^{-1})	23.50
Available K (kg ha^{-1})	195.40

Table 2: Nutrient status of the organic manures used in the experiment.

Name of the manure	Nutrient composition (%)		
	N	P_2O_5	K_2O
Farm Yard Manure (FYM)	0.4	0.20	0.20
Vermicompost (VC)	2.0	1.0	1.0
Poultry manure (PM)	2.0	1.2	1.2
Sheep Manure (SM)	0.60	0.3	0.03
Dal weed (DW)	0.36	0.19	0.14

The experiment was conducted in Randomized Complete Block Design with three replications for two consecutive years without changing the site of the experiment for studying the residual effect of applied inputs. The treatment combinations comprised of thirteen nutrient management practices through different sources (Table-3).

The brinjal was taken as main crop and all the nutrients, organic as well inorganic were applied to it. The fenugreek was raised as residual crop to study the carry over effect of applied fertilizers. The well decomposed farm yard manure (FYM), vermicompost (VC), poultry manure (PM), sheep manure (SM) and dal weed (DW) were applied two weeks before sowing and incorporated in soil as per treatments either alone or in combination with other organic as well as inorganic sources of fertilizers. Brinjal cv. Local Long was transplanted at the spacing of 60 cm x 45 cm during kharief 2012 and 2013. The residual crop fenugreek cv. Early Bunching was sown in rows 30 cm apart during rabi 2012 and 2013. Other management practices were adopted as per recommendations for crops under irrigated conditions. The soil was analyzed after harvesting of the crop to find out the change in available nutrient (N, P and K) status. Data obtained from consecutive two years were statistically analyzed by using the F-test as per the procedure given by Gomez and Gomez (1984) [4]. LSD at P=0.05 were used to determine the significance differences between treatment means.

Table 3: Treatment combination for brinjal-fenugreek cropping system

Symbol		Structure		Quantity
T_1	:	Farmyard manure (FYM)	:	38 t ha^{-1}
T_2	:	Vermicompost (VC)	:	8 t ha^{-1}
T_3	:	Poultry manure (PM)	:	8 t ha^{-1}
T_4	:	Sheep manure (SM)	:	25 t ha^{-1}
T_5	:	Dal weed (DW)	:	20 t ha^{-1}
T_6	:	Integration of all organic manures	:	7.5 t FYM+ 1.5 t VC ha^{-1}+ 1.5 t PM h ha^{-1}+ 5 t SM ha^{-1}+ 4 t DW ha^{-1}
T_7	:	50% RFD + 50% FYM	:	75:60:60 N:P_2O_5:K_2O kg ha^{-1} + 19 t ha^{-1}
T_8	:	50% RFD + 50% VC	:	75:60:60 N: P_2O_5:K_2O kg ha^{-1} + 4 t ha^{-1}
T_9	:	50% RFD + 50% PM	:	75:60:60 N: P_2O_5:K_2O kg ha^{-1} + 4 t ha^{-1}
T_{10}	:	50% RFD + 50% SM	:	75:60:60 N: P_2O_5:K_2O kg ha^{-1} + 12.5 t ha^{-1}
T_{11}	:	50% RFD + 50% DW	:	75:60:60 N: P_2O_5:K_2O kg ha^{-1} + 10 t ha^{-1}
T_{12}	:	RFD	:	150:120:120 N: P_2O_5:K_2O kg ha^{-1}
T_{13}	:	Control	:	No chemical fertilizers/organic manures

Methods of chemical analysis

Soil pH was measured by digital pH meter using soil: water ratio of 1:2.5 (Jackson, 1973) [5]. Organic carbon was determined by wet oxidation method as described by Walkley and Black (1935). Electrical conductivity was estimated by solubridge conductivity meter (Jackson, 1973) [5]. Available nitrogen was determined by alkaline potassium permanganate method as described by Subbiah and Asija (1956). Available phosphorus was determined by Olsen method (Olsen *et al.,* 1954) and available potassium was determined by extracting it with neutral normal ammonium acetate (Merwin and Peech, 1950) and determined by flame photometer as outlined by Jackson (1973) [5]. The total nutrient in manure samples were determined by digesting with concentrated nitric and perchloric acid mixture (Yoshida *et al*, 1976) [19].

Results and Discussion

The growth, yield and yield components of fenugreek were influenced significantly due to integrated use of chemical fertilizers and organic manures. The results have been presented in Table 4 & Table 5 and are discussed as follows.

Residual effect of treatments on growth and yield parameters of fenugreek

Referring to Table-4, data revealed that all the growth parameters of fenugreek viz. plant height and number of branches plant^{-1} were significantly influenced by different treatment combinations. The treatment T_9 receiving nutrients through poultry manure and inorganic fertilizers on equivalent basis (50:50) recorded the maximum plant height of 34.01cm and number of branches of 5.40 plant^{-1} which was higher than all other treatments, viz. sole organic, sole inorganic and integrated treatments followed by treatment T_8 (50% RFD + 50% VC) recording 31.80cm and 4.95 plant height and number of branches plant^{-1}, respectively. Among all the treatments of sole and integrations, Treatment T_{12} (RFD) recorded least plant height of 18.98cm and number of branches of 3.02 per plant. The percent increase of treatment T_9 over Treatment T_{12} (RFD) for plant height and number of branches plant^{-1} was 79.18, 78.80 percent, respectively. The Lowest values were recorded with control receiving no inputs. As far as yield is concerned the same treatment T_9 (50% RFD+ 50% PM) observed the highest yield and was significantly superior to all other treatments under study. The maximum yield ha^{-1} (52.27 q) was observed in treatment T_9 (50% RFD+ 50% PM) followed by treatment T_8 (50% RFD+ 50% VC) indicating the higher availability of residual nutrients in the said treatment. Treatment T_{12} (RFD) recorded yield of 31.50q per hectare which was significantly lower than other sole organic and integrated treatments, depicting lesser residual effect of chemical fertilizers. The days taken by crop to reach harvesting stage was minimum in treatment T_9 (132.53 days) which implies that there were sufficient residual nutrients available to the crop which resulted in its fast growth. The treatment T_{12} (RFD) took maximum days (164.41) to reach harvesting stage indicating poor growth of crop due to lesser availability of nutrients.

The increased growth and vigour of the succeeding crop was due to the availability of residual nutrients leading to better development which in turn increased the yield of succeeding crop. The results are in conformity with findings of Choudhary *et al.* (2011) [1]. Parihar *et al.* (2009) [10] also reported that nutrient management of preceding crop had marked influence on growth and yield of unfertilized succeeding crop due to continued supply of residual nutrient. These findings reveal that organic manure applied to preceding crop had residual effect on succeeding crop which improved yield attributes of plants raised in plots that had experienced substitution of nutrients through organic sources in the preceding crop. This is due to the presence of highly persistent material i.e. cellulose in organic manures which requires long time for complete decomposition. Thus, those nutrients released from organic manures for long period notably benefited the succeeding crop. Similar findings have also been reported by Panwar (2008) [11] and Chattoo *et al.* (2009) [2].

Residual effect of treatments on quality parameters of fenugreek:

It is apparent from the data presented in Table-5 that organic manures depicted significant residual effect on quality of fenugreek. Maximum values for vitamin C (64.63 mg 100g^{-1}), protein content (6.49%), dry matter content (13.74%), and chlorophyll content (15.42 mg 100g^{-1}) of fenugreek leaves were observed in treatment T_6 (integration of organic manures) followed by treatment T_3 (PM). Among integration of organic manures with inorganic fertilizers, treatment T_9 (50% RFD+ 50% PM) recorded higher values of 54.22 mg 100 g^{-1}, 6.14 percent, 10.40 percent and 12.48 mg 100 g^{-1} for vitamin C content, protein content, dry matter content and chlorophyll content, respectively followed by treatment T_8 (50% RFD+ 50% VC). Recommended fertilizer dose (T_{12}) resulted in poor quality of fenugreek as compared to sole organic and integration of organic and inorganic fertilizers indicating scarcity of nutrients in the said treatment.

The improvement in quality due to organic manures can be attributed to the slow decomposing nature of manures making the nutrients both macro and micro available throughout the crop growth. Also the physical and biological properties of the soil get enhanced due to organic matter added. Also the organic manures are considered as the store house of beneficial microorganisms. These microorganisms are of significance due to their nitrogen fixing ability, nutrient cycling, mobilizing and also increase the uptake of phosphorus. They also produce certain bioactive compounds such as vitamins, enzymes, hormones along with antifungal and antibacterial substances that stimulate the plant growth and are responsible for improvement in quality. Similar findings have been reported by Tien *et al.*, 1979 [17]; Narula *et al.*, 1980 [8]; Sharma *et al.*, 1986 [14]; Pandey and Kumar, 1989 [12]; Kamlakannan and Manivannan, 2003 [6]; Sharma *et al.*, 2008 [15].

Table 4: Residual effect of organic manures and inorganic fertilizers on growth, yield and yield attributing parameters of fenugreek (pooled data of rabi 2012 & 2013).

Treatments	Plant height (cm)	No. of branches/ plant	Leaf yield plot^{-1} (kg)	Leaf yield (q ha^{-1})	Days to harvesting (days)
T_1	24.96	3.66	3.02	37.32	157.33
T_2	26.31	3.95	3.18	39.34	154.58
T_3	27.23	4.20	3.41	42.15	153.20
T_4	22.25	3.36	2.83	34.98	161.45
T_5	19.78	3.15	2.70	33.37	165.43
T_6	28.48	4.37	3.57	44.15	144.56
T_7	29.61	4.55	3.81	47.05	141.55
T_8	31.80	4.95	3.90	48.18	135.46
T_9	34.01	5.40	4.23	52.27	132.53
T_{10}	23.41	3.50	3.04	37.50	159.56
T_{11}	21.68	3.35	2.81	34.75	163.05
T_{12}	18.98	3.02	2.55	31.50	164.41
T_{13}	17.21	2.92	1.61	19.88	169.03
$C.D_{(p\leq 0.05)}$	1.49	0.28	0.068	0.83	2.75

Table 5: Residual effect of organic manures and inorganic fertilizers on quality of fenugreek (pooled data of rabi 2012 & 2013).

Treatments	Vitamin C (mg 100 g^{-1})	Protein content (%)	Dry matter content (%)	Chlorophyll (mg 100 g^{-1})
T_1	58.91	6.18	12.79	13.88
T_2	60.98	6.26	13.03	14.22
T_3	62.78	6.34	13.20	14.68
T_4	57.40	5.71	12.44	13.42
T_5	55.74	5.61	12.25	13.17
T_6	64.63	6.49	13.74	15.42
T_7	51.45	5.43	9.74	11.55
T_8	52.91	5.79	10.03	12.38
T_9	54.22	6.14	10.40	12.48
T_{10}	51.00	5.22	9.45	11.72
T_{11}	50.46	5.10	8.96	11.23
T_{12}	50.15	5.32	8.07	10.37
T_{13}	46.53	4.51	6.53	9.74
$C.D_{(p\leq 0.05)}$	0.51	0.11	0.34	0.29

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