Original Research Article

Effect of STCR-IPNS Based Nutrient application on Soil Health, Yield, Nutrient Content and Uptake of Mustard (*Brassica juncea* L.) in eastern plain zone of Uttar Pradesh, India

Abstract

The improvement in grain yield characters was the manifestation of improved growth characters as a result of higher uptake of nutrients caused by balanced supply of nutrients in this regard soil test based nutrient management approaches aims provide a scientific basis for balanced fertilization to obtain more yield per unit of fertilizer investment. An experiment was conducted during kharif season 2017-18 in the Soil Science and Agricultural Chemistry Research Farm, SHUATS, Prayagraj. The cursory glance of data revealed that the bulk density and particle density of soil was found to be non-significant in different levels of fertilizer recommendation based on soil test values. The maximum soil pore space (60.37%) and water retaining capacity (81.25 %) was recorded in treatment T_4 [STCR + 5 t FYM]. The maximum available Nitrogen (305.82 kg ha^{-1}), available Phosphorus (26.90 kg ha^{-1}), available Potassium (205.07 kg ha^{-1}) and available Sulphur (14.23 ppm ha^{-1}) in soil was recorded in treatment T_8 [STCR + @ 50 % FYM + @ 50 % S]. The maximum seed yield of mustard (11.53 q ha^{-1}) and stover yield (16.03 q ha^{-1}) was associated with the treatment T_8 [STCR + @ 50 % FYM + @ 50 % S]. Result showed that that application of T_8 [STCR + @ 50 % FYM + @ 50 % S] significantly recorded maximum nutrient content viz. N (2.19%), P (0.23%), K (1.68%) and S (4.8%) content in grain N (1.73%), P (0.21%), K (1.47%) and S (3.9%) content in stover and maximum nutrient uptake viz. N (25.25 kg ha^{-1}), P (2.65 kg ha^{-1}), K (19.37 kg ha^{-1}) and S (55.34 kg ha^{-1}) uptake in grain is and N (27.73 kg ha^{-1}), P (3.36 kg ha^{-1}), K (23.56 kg ha^{-1}) and S (62.51 kg ha^{-1}) uptake in stover.

Key Words: Mustard, Nutrient Content, Nutrient Uptake, STCR and Yield

Introduction

Rapeseed-mustard (*Brassica campestris*) is a major oilseed crop contributing important share in oilseed production in the country. Production of rapeseed and mustard declined from 8.03 MT in 2012-13 to 6.82 MT in 2015-16 **(Anonymous 2016-17).**

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India is amongst the largest vegetable oil economic in the world. The present average per capita consumption of oils and fats has not been more than 11g day^{-1} as against the nutritional standard of 30g/day for a balanced diet. Mustard is rich in minerals like calcium, manganese, copper, iron, selenium, zinc, vitamin A, B, C and proteins. 100g mustard seed contains 508 kcal energy, 28.09 Mg carbohydrates, 26.08g proteins, 36.24g total fat and 12.2g dietary fiber. (**Upadhyay *et al.*, 2016)**

The nutrient elements of major significance for yield and quality of yellow mustard are nitrogen, phosphorus sulphur and Zinc. Nitrogen is the most important which determines the growth of yellow mustard that increases the amount of protein, methionine, dry matter and yield. Phosphorus and potash are known to be efficiently utilized in the presence of nitrogen to promote flowering, setting of siliqua and increases the size of siliqua and yield. **(Singh *et al.*, 2012)**

Sulphur is considered to occupy fourth place among major plant nutrient after nitrogen, phosphorus and potassium. It increases phosphorus uptake by plant and nitrogen in protein synthesis and is indispensable for the synthesis of essential amino acid like cysteine and methionine. Besides, sulphur is also involved in various metabolic processes of plants. It is a constituent of glutathione, a compound supposed to be associated with the plant respiration and the synthesis of essential oils. Sulphur also plays a vital role in chlorophyll formation. **(Yadav *et al.*, 2017)**

There are several reasons behind such yield reduction including poor soil nutrient status. Soil fertility declination under continuous cropping has been witnessed which need to be restored for sustaining and increasing crop yield. Soil fertility restoration can effectively be achieved by integrated management of nutrient sources **(Joshi *et al*., 2017),** but due to lack of proper knowledge of method and time of manuring and fertilizer application; the cost of cultivation increased. Soil fertility maintenance required adequate knowledge of soil nutrient status, fertilizer efficiency soil efficiency, time and methods of fertilizer application. Adoption of soil test crop response (STCR) suggested by **Ramamoorthy *et al*. (1967)** is efficient approach concerning all aspects of nutrient management. Supplying of plant nutrients based on STCR approach significantly improved crop yield as well as soil health **(Rajput *et al*. 2016)** and is very important for yield sustainability and reducing fertilizer cost **(Saxena *et al*., 2008).** Implementation of inductive approach of STCR in Chhattisgarh may reduce cost of cultivation and may also encourage smart and strategic nutrient management practices.

In the targeted yield approach, it is assumed that there is linear relationship between grain yield (economic produce) and nutrient uptake by the crop. Targeted yield concept, thus strikes a balance between “Fertilizing the crop” and “Fertilizing the soil”. This approach can be used not only for individual field situations but also as a better approximation for planning the requirement of fertilizers on area basis for a given level of crop production. Fertilizer application and the yield targets chosen can be so manipulated that both high profits from fertilizer investment and maintenance of soil fertility can be achieved **(Velayutham 1979).** The targeted yield approach has been used to formulate fertilizer recommendations across the country **(Puri *et al.* 1993, 1994; Verma and Bhagat 1995; Verma *et al.* 2017; Singh *et al.* 2017).**

Resources and Methods

Soil of Experimental Field

The soil of experimental field is sandy loam in texture, good aeration (47.53 % porosity), alkaline in reaction (pH 7.58), low in organic carbon (0.45%), low in available N (238.21 kg ha^{-1}), medium in available P (20.73 kg ha^{-1}), high in available K (127.65 kg ha^{-1}) and low in available sulphur (9.82 ppm ha^{-1}).

Layout and Design of the Experiment

The experiment was laid out in randomized block design with three replications. The total numbers of unit plots were 27. The size of a unit plot was 2.0 m X 2.0 m. The width of the main irrigation channel is 1.0 m and the width of the sub-irrigation channel is 0.5 m.

Treatments of the Investigation:

Table 1: Treatment Combination

S. No.	Symbol	Description
1.	T_0	[Control]
2.	T_1	[RDF + 5 t FYM]
3.	T_2	[STL + 5 t FYM]
4.	T_3	[FP + 5 t FYM]
5.	T_4	[STCR + 5 t FYM]
6.	T_5	[RDF + 5 t FYM + 50 % S]
7.	T_6	[STL + 5 t FYM + 50 % S]
8.	T_7	[FP + 5 t FYM + 50 % S]
9.	T_8	[STCR + 5 t FYM + 50 % S]

RDF- Recommended dose of fertilizers (80:40:40 kg ha^{-1})

STL- Soil Test Levels (80:28:28 kg ha^{-1})

FP- Farmer's Practice (50:30:30 kg ha^{-1})

STCR- Soil Test Crop Response (40:15:15 kg ha^{-1})

STCR approach

The following STCR equation developed for Mustard was used for achieving 25 q ha^{-1} yield target.

With FYM

1. Nitrogen dose (kg ha^{-1}) =12.27T-0.56SN-0.09FYM-N

2. Phosphorus dose (kg ha^{-1}) = 4.60T-3.29SP-0.06FYM-P

3. Potassium dose (kg ha^{-1}) = 4.69T-0.24SK-0.05FYM-K

Where, T = Yield target (q ha^{-1}), SN = Alkaline $KMnO_4$-N, SP= Olsen's P (kg ha^{-1}) and SK =Ammonium Acetate - K (kg ha^{-1}).

The fertilizer adjustment equations were ready for determining requirement of fertilizer. Say for 25 q ha^{-1} the yield target of mustard with varying soil test values in table 3.5. These results were shows that the fertilizer requirement varies with the soil test values for a particular target yield. Similar result was also reported by **Mishra *et al*. (2010) and Singh *et al.* (2014).**

1. **Nutrient Requirement**
   - **a.** Kg N required per quintal of seed Production = Total uptake of N (kg ha^{-1}) / Seed yield (q ha^{-1})
   - **b.** Kg P required per quintal of seed Production = Total uptake of P (kg ha^{-1}) / Seed yield (q ha^{-1})
   - **c.** Kg K required per quintal of seed Production = Total uptake of K (kg ha^{-1}) / Seed yield (q ha^{-1})

Preparation and analysis of soil samples

Soil samples from each plot at 0-15 cm depth were collected at different stages were air-dried, grind and passed through 2 mm sieve and finally stored in polythene bags for analysis of different physico-chemical parameters and changes in available N, P, K and % Organic carbon content. The soil sample was analyzed for Bulk density **(Muthuaval *et.al.*, 1992),** particle density **(Muthuaval *et.al.*, 1992),** % pore space **(Muthuaval *et.al.*,1992),** soil texture **(Bouyoucos Hydrometer Method, 1952)** , pH **(Jackson, 1973),** Available N **(Subbaih and Asija, 1956)**, P **(Olsen *et al*., 1954),** K **(Toth and Price, 1949)** and S **(Bardsley and Lancaster, 1960).**

Plant Analysis for Content and Uptake of Nutrient

The chemical analysis of plants for the nutrient content was done when grain and straw samples were collected from each treatment at harvest to analyse nitrogen, phosphorous, potassium concentration (%) and sulphur concentration (ppm) and their uptake (kg ha^{-1}). The plant material was oven dried (70 ± 5^0C for 72 hours) and ground separately and then subjected to analysis. Plant analysis for the determination of nutrient content in grain and stover were done with the standard procedures viz., nitrogen concentration in plant (both grain and stover) was determined by micro-kjeldahl's method **(Jackson, 1973),** phosphorus by vanado-molybdo phosphoric acid yellow colour method **(Jackson, 1973),** potassium by flame photometer **(Jackson, 1973)** and sulphur by Turbidometric Method **(Jackson, 1973).** The uptake of nitrogen, phosphorus, potassium and sulphur were calculate by the following formulas:

$$\textbf{Nutrient uptake (N, P, K kg ha}^{-1}\textbf{)} = \frac{\textbf{Nutrient content in grain and straw (\%)} \times \textbf{Seed and Stover Yield (kg ha}^{-1}\textbf{)}}{\textbf{100}}$$

Nutrient response ratio (kg yield kg nutrient^{-1})

It was calculated by using following equation **(Indian Society of Agronomy, New Delhi).**

$$\textbf{NRR} = \frac{\textbf{Yield (kg)}}{\textbf{Amount of nutrient applied (kg)}}$$

Result and Discussion

1. **Physical Properties of Soil**

It is obvious from the data given in table-2 and depicted in fig.1 clearly shows that response Bulk density and Particle density of soil was found to be non-significant in different levels of fertilizer recommendation based on soil test values. The maximum Bulk density (1.09 Mgm^{-3}) and Particle density (2.73 Mgm^{-3}) of soil was recorded in treatment T_2 [STL + 5 t FYM] and minimum Bulk density (1.03 Mgm^{-3}) and Particle density (2.24 Mgm^{-3}) of soil was recorded in treatment **[STCR + 5 t FYM + 50 % S].** Similar results were also reported by **Nagar *et al.*, (2015) and Sahu *et al.*, (2015)** The response of soil pore space and water retaining capacity (WRC) was found to be significant in different levels of fertilizer recommendation based on soil test values. The maximum soil pore space (60.37 %) and maximum WRC (81.25%) was recorded in treatment T_4 [STCR + 5 t FYM] and minimum soil pore space (52.63 %) and minimum WRC (60.00%) was recorded in treatment T_7 [FP + 5 t FYM + 50 % S]. The results of the present investigation are also in agreement with the findings of **Ahmadi and David (2016) and Alam *et al.*, (2014).**

Table 2: Effect of different levels of fertilizer recommendation based on soil test values on physical properties of soil after crop harvest.

Treatments	BD (Mg m^{-3})	PD (Mg m^{-3})	% PS	WRC (%)
T_0	1.04	2.35	53.62	73.33
T_1	1.07	2.45	55.45	75.00
T_2	1.09	2.73	60.04	61.11
T_3	1.09	2.52	56.33	69.23
T_4	1.04	2.62	60.37	81.25
T_5	1.05	2.36	54.58	68.75
T_6	1.05	2.45	56.16	62.50
T_7	1.05	2.35	52.63	60.00
T_8	1.03	2.24	53.51	75.00
F-test	**NS**	**NS**	**S**	**S**
S. Em±	**0.025**	**0.171**	**0.169**	**1.38**
C.D. (P= 0.05)	**0.054**	**0.362**	**0.359**	**2.94**

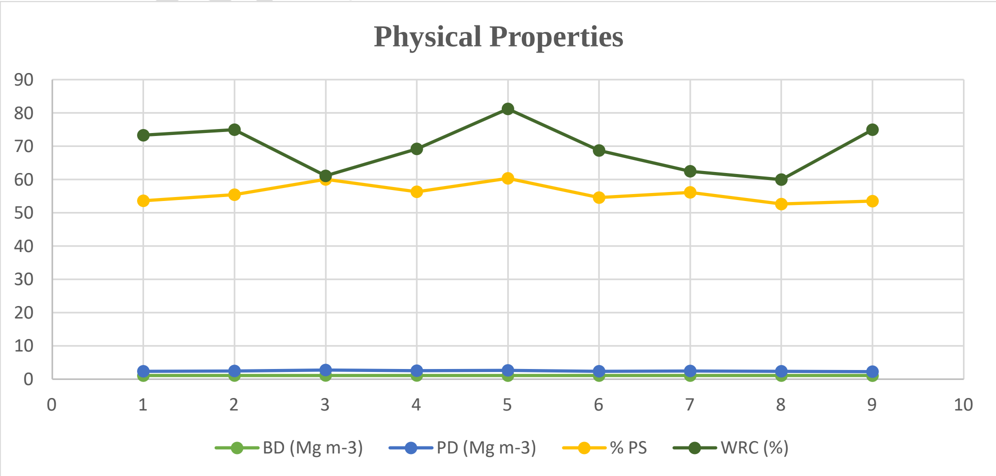

Fig. 1: Effect of different levels of fertilizer recommendation based on soil test values on physical properties of soil after crop harvest.

2. **Chemical Properties of Soil**

An appraisal of the data given in table 3 and depicted in fig. 2 clearly shows that available N, P, K and S in soil increased significantly with the increase in different levels of fertilizer recommendation based on soil test values. The maximum available N (305.82 Kg ha^{-1}), available P (26.90 Kg ha^{-1}), available K (205.07 Kg ha^{-1}) and available S (14.23 ppm ha^{-1}) in soil was recorded in treatment T_8 [STCR + 5 t FYM + 50 % S] and the minimum available N (289.13 Kg ha^{-1}), available P (19.10 Kg ha^{-1}), available K (183.97 Kg ha^{-1}) and available S (10.43 ppm ha^{-1}) in soil was recorded in treatment T_0 [control]. The consequences of the current investigation are additionally in concurrence with the investigation of **Upadhyay *et al.*, (2015), Rajput *et al.*, (2016) and P. Dey (2016)**

Table 3: Effect of different levels of fertilizer recommendation based on soil test values on Chemical Properties of soil after crop harvest.

Treatments	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (ppm ha^{-1})
T_0	289.13	19.10	183.97	10.43
T_1	299.46	23.95	196.63	11.40
T_2	302.51	25.03	202.50	13.40
T_3	297.46	22.90	192.43	10.73
T_4	300.52	24.11	197.07	12.30
T_5	303.86	25.75	203.47	13.47
T_6	298.83	23.93	193.07	10.97
T_7	301.16	24.70	198.20	12.87
T_8	305.82	26.90	205.07	14.23
F-test	**S**	**S**	**S**	**S**
S. Em±	**0.980**	**0.311**	**0.430**	**0.060**
C.D. (P= 0.05)	**2.078**	**0.661**	**0.912**	**0.127**

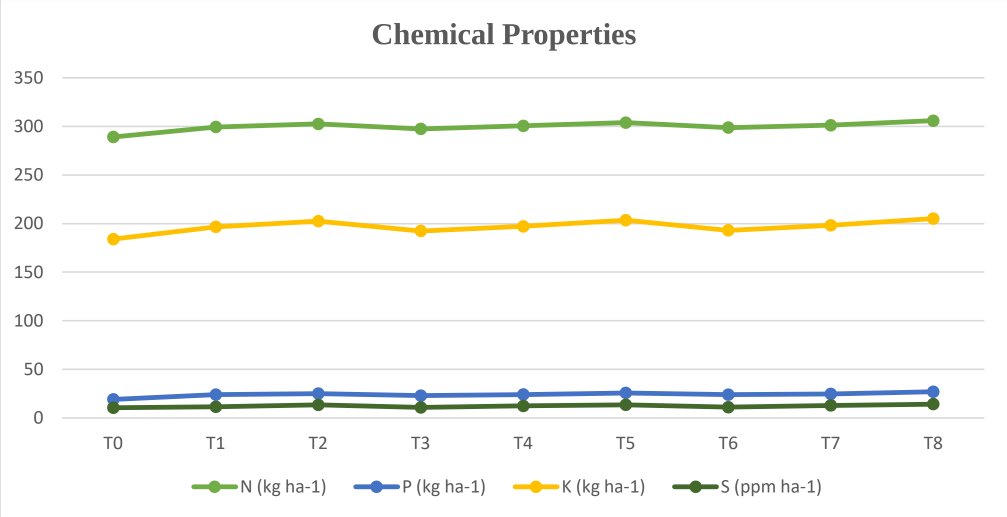

Fig. 2: Effect of different levels of fertilizer recommendation based on soil test values on Chemical properties of soil after crop harvest.

3. Seed and Stover Yield (q ha^{-1})

It is visualized from the data given in table-4 and depicted in fig. 3 that Seed Yield and of Mustard was found to be increased significantly but stover yield of mustard was found to be non-significant with the increase in different levels of fertilizer recommendation based on soil test values. The maximum Seed Yield (11.53 q ha^{-1}) and maximum Stover Yield (16.03 q ha^{-1}) was recorded as in T_8 [STCR + 5 t FYM + 50 % S] and the minimum Seed Yield (9.33 q ha^{-1}) and Stover yield (13.77 ha^{-1}) was recorded as inT_0 [control]. Comparative findings were detailed by **Kumar *et al.*, (2016) and Pal and Pathak (2016).**

Table 4: Effect of different levels of fertilizer recommendation based on soil test values on Seed Yield (q ha^{-1})

Treatment	Seed Yield (q ha^{-1})	Stover Yield (q ha^{-1})
T_0	9.33	13.77
T_1	9.53	15.13
T_2	9.83	15.33
T_3	9.47	14.90
T_4	11.13	15.53
T_5	9.67	15.20
T_6	9.50	15.10
T_7	9.70	15.23
T_8	11.53	16.03
F-test	**S**	**NS**

S. Em±	**0.222**	**0.395**
C.D. (P= 0.05)	**0.472**	**0.836**

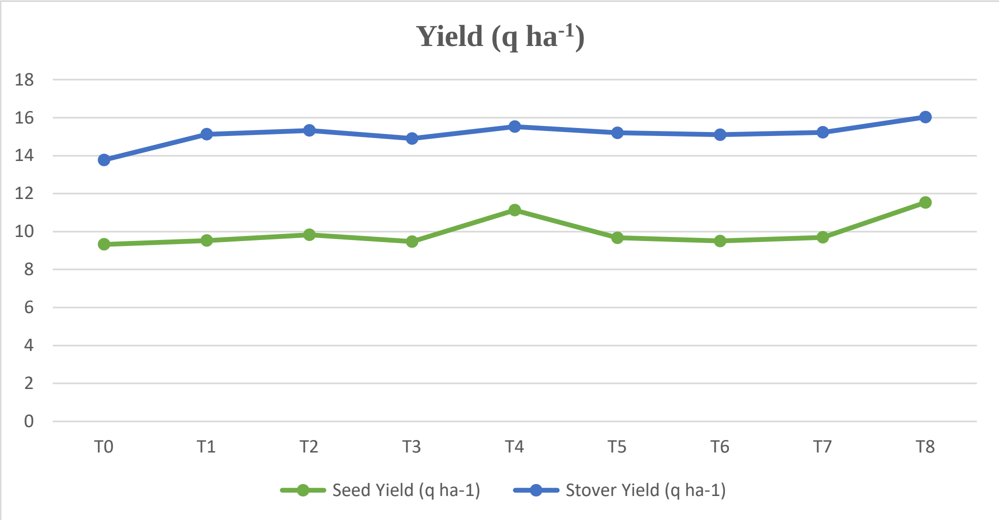

Fig. 3: Effect of different levels of fertilizer recommendation based on soil test values on yield of mustard.

4. Plant Nutrient Concentration

A critical perusal of the data given in table-5 and depicted in fig. 4 clearly shows the nutrient concentration (N, P, K and S) in Stover and grain increased significantly with the increase in different levels of fertilizer recommendation based on soil test values. The maximum N (1.73% in Stover and 2.19 % in grain), P (0.21% in Stover and 0.23 % in grain), K (1.47% in Stover and 1.68 % in grain) and S (3.9 % in Stover and 4.8 % in grain) in treatment T_8 [STCR + 5 t FYM + 50 % S] which was significantly higher than any other treatment combination and the minimum N (1.05% in Stover and 1.18 % in grain), P (0.12% in Stover and 0.14 % in grain), K (1.08% in Stover and 1.19 % in grain) and S (2.8 % in Stover and 4.0 % in grain) was recorded in treatment T_0 [control]. The results of the present investigation are also in agreement with the findings of **Bharose *et al.*, (2011) and Chaurasia *et al.*, (2009)**

Table 5: Effect of different levels of fertilizer recommendation based on soil test values on Nutrient Concentration in Stover and Grain.

Treatments	**N (%)**		**P (%)**		**K (%)**		**S (%)**	
	Stover	**Grain**	**Stover**	**Grain**	**Stover**	**Grain**	**Stover**	**Grain**
T_0	1.05	1.18	0.12	0.14	1.08	1.19	2.8	4.0
T_1	1.17	1.44	0.14	0.16	1.11	1.21	3.1	4.2

T_2	1.40	1.59	0.15	0.18	1.15	1.30	3.0	4.1
T_3	1.14	1.70	0.14	0.17	1.17	1.27	3.4	4.3
T_4	1.61	1.99	0.17	0.21	1.39	1.57	3.7	4.6
T_5	1.50	1.82	0.16	0.18	1.32	1.37	3.5	4.4
T_6	1.53	1.77	0.15	0.15	1.21	1.44	3.2	4.3
T_7	1.57	1.82	0.16	0.19	1.26	1.51	3.6	4.6
T_8	1.73	2.19	0.21	0.23	1.47	1.68	3.9	4.8
F-test	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
S. Em±	**0.08**	**0.07**	**0.01**	**0.01**	**0.06**	**0.07**	**0.14**	**0.15**
C.D. (P= 0.05)	**0.25**	**0.21**	**0.03**	**0.03**	**0.19**	**0.20**	**3.15**	**3.19**

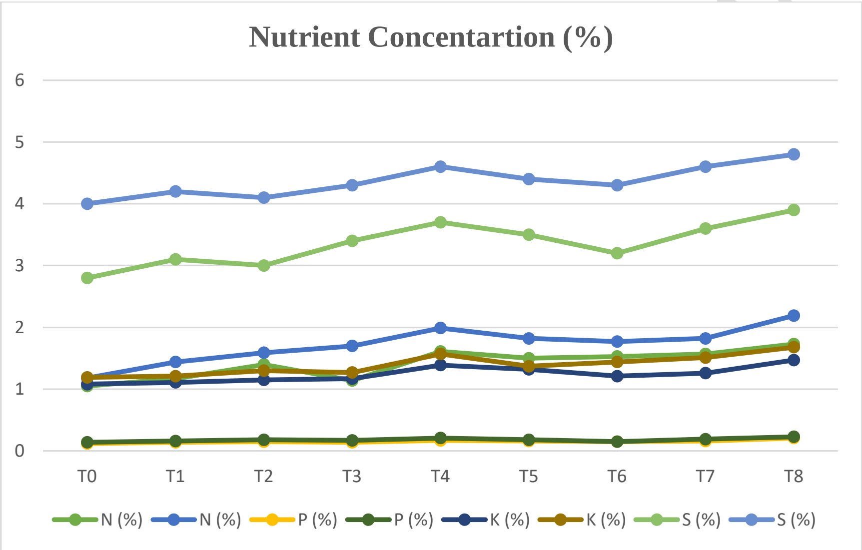

Fig. 4: Effect of different levels of fertilizer recommendation based on soil test values on nutrient content in grain and stover.

5. Nutrient uptake by Grain and Stover of Mustard

At a glance over the data given in the table-6 and depicted in fig. 5 clearly shows the nutrient uptake (N, P, K and S) in Stover and grain increased significantly with the increase in different levels of fertilizer recommendation based on soil test values. The maximum uptake of N (27.73 kg ha^{-1} in Stover and 25.25 kg ha^{-1} in grain), P (3.36 kg ha^{-1} in Stover and 2.65 kg ha^{-1} in grain), K (23.56 kg ha^{-1} in Stover and 19.37 kg ha^{-1} in grain) and S (62.51 kg ha^{-1} in Stover and 55.34 kg ha^{-1} in grain) in treatment T_8 [STCR + 5 t FYM + 50 % S] which was significantly higher than any other treatment combination and the minimum uptake N (14.45 kg ha^{-1} in Stover and 11.00 kg ha^{-1} in grain), P (1.65 kg ha^{-1} in Stover and 1.30 kg ha^{-1} in grain), K (14.87 kg ha^{-1} in Stover and 11.10 kg ha^{-1}

in grain) and S (38.55 kg ha^{-1} in Stover and 37.32 kg ha^{-1} in grain) was recorded in treatment T_0 [control]. The consequences of the current investigation are additionally in concurrence with the investigation of **Raghvendra *et al.*, (2017) and Dhruw *et al.*, (2018)**

Table 6: Effect of different levels of fertilizer recommendation based on soil test values on Nutrient Uptake in Stover and Grain.

Treatments	N (kg ha^{-1})		P (kg ha^{-1})		K (kg ha^{-1})		S (kg ha^{-1})	
	Stover	Grain	Stover	Grain	Stover	Grain	Stover	Grain
T_0	14.45	11.00	1.65	1.30	14.87	11.10	38.55	37.32
T_1	17.70	13.72	2.11	1.52	16.79	11.53	46.90	40.02
T_2	21.46	15.62	2.29	1.76	17.62	12.77	45.99	40.30
T_3	16.98	16.09	2.08	1.60	17.43	12.02	50.66	40.72
T_4	25.00	22.14	2.64	2.33	21.58	17.47	57.46	51.19
T_5	22.80	17.55	2.43	1.74	20.06	13.24	53.20	42.54
T_6	23.10	16.81	2.26	1.42	18.27	13.68	48.32	40.85
T_7	23.91	17.65	2.43	1.84	19.18	14.64	54.82	44.62
T_8	27.73	25.25	3.36	2.65	23.56	19.37	62.51	55.34
F-test	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
S. Em±	**0.05**	**0.10**	**0.04**	**0.07**	**0.36**	**0.29**	**1.01**	**0.17**
C.D. (P= 0.05)	**0.16**	**0.32**	**0.14**	**0.23**	**1.09**	**0.89**	**3.06**	**0.54**

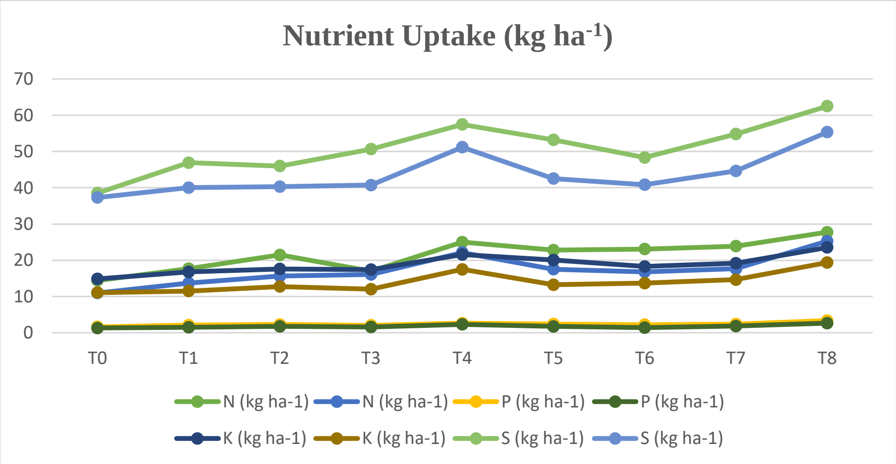

Fig. 5: Effect of different levels of fertilizer recommendation based on soil test values on nutrient uptake by grain and stover.

6. Nutrient Response Ratio (kg kg^{-1})

It is apparent from the data given in table-7 and depicted in fig. 6 clearly shows that the nutrient response ratio (kg kg^{-1}) was found to be increased significantly with the increase in different levels of fertilizer recommendation based on soil test values. The maximum total nutrient response ratio was recorded as 436.36 kg kg^{-1} in T_8 [STCR + 5 t FYM + @ 50 % S] followed by T_4 [STCR + 5 t FYM] with the total NRR value 244.37 kg ka^{-1} and the minimum total nutrient response ratio was recorded as 146.22 kg kg^{-1} in T_3 [FP + 5 t FYM].

Table 7: Effect of different levels of fertilizer recommendation based on soil test values on Nutrient Response Ratio (kg kg^{-1})

Treatment	Nitrogen Response Ratio (kg kg^{-1})	Phosphorus Response Ratio (kg kg^{-1})	Potassium Response Ratio (kg kg^{-1})	Total Nutrient Response Ratio (kg kg^{-1})
T_0	-	-	-	-
T_1	30.83	61.65	61.65	154.13
T_2	31.45	89.85	89.85	211.15
T_3	48.74	48.74	48.74	146.22
T_4	66.65	88.86	88.86	244.37
T_5	31.08	62.17	62.17	155.42
T_6	30.82	88.07	88.07	206.96
T_7	49.86	83.10	83.10	216.06
T_8	68.90	183.73	183.73	436.36
F-test	**S**			
S. Em±	**16.62**			
C.D. (P= 0.05)	**35.23**			

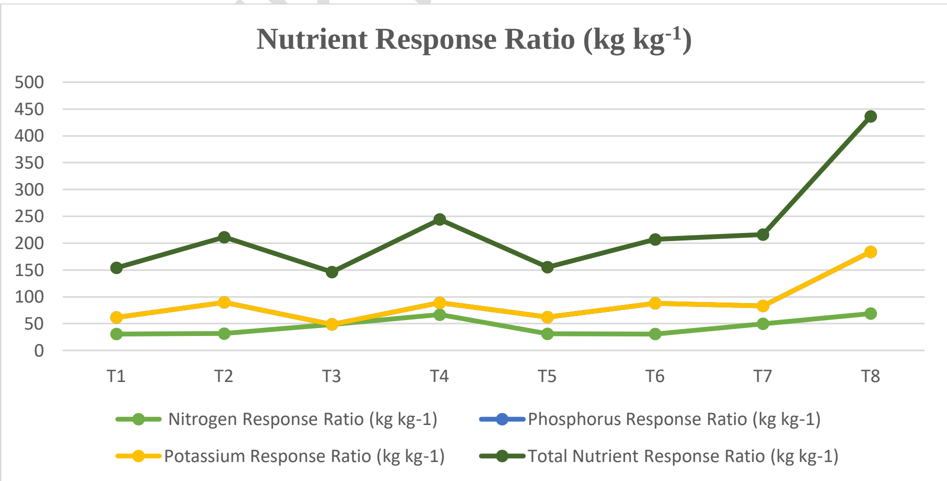

Fig. 6: Effect of different levels of fertilizer recommendation based on soil test values on Nutrient Response Ratio (kg kg^{-1})

Conclusion

Based on the results and corroboration with previous studies, it could be concluded that STCR based integrated nutrient management not only gave higher crop yield but also support the nutrient content of the soil after crop harvest. Our results also highlight the higher nutrient content and uptake in seed and stover in T_8 [STCR + 5 t FYM + @ 50 % S] where fertilizers were supplemented with FYM which is at par with T_4 [STCR + 5 t FYM].

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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