Indian J. Dryland Agric. Res. & Dev. 2016 31(1) : 09-14 DOI 10.5958/2231-6701.2016.00002.6

Long Term Effect of Integrated Nutrient Management on Soil Properties and Productivity of Toria (*Brassica campestris*) in an Inceptisol under Rainfed Upland Condition of North Bank Plains Zone of Assam

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ABSTRACT: A field experiment was conducted to study the effect of integrated nutrient management on soil properties and productivity of toria at Biswanath College of Agriculture, Biswanath Chariali, Assam. The experiment was carried out during 2010-11 to 2014-15 in Randomised Block Design with eleven treatment combinations and three replications consisting of organic and inorganic inputs. The soil of the experimental site was sandy loam in texture with acidic in reaction (pH 5.05). The initial fertility status of soil was medium in available N (385.73 kg/ha), medium in available P (12.33 kg/ha) and medium in available K (148.08 kg/ha). After five years of experimentation increasing fertility trend was observed under T_4 (75% RDF + 5 t/ha vermicompost) treatment. The application of 75% RDF + 5 t/ha vermicompost (T_4) recorded significantly higher yield, benefit cost ratio, Rain Water Use Efficiency (RWUE) along with significant improvements in soil physical and chemical properties. However, application of vermicompost @ 3 t/ha along with 75% RDF also sustained the toria productivity and was at par with application of 75% RDF + vermicompost @ 5 t/ha in respect of toria productivity and soil properties.

Key words: Integrated nutrient management, toria, yield, B-C ratio, RWUE, soil properties, inceptisol

Introduction

Rapeseed and mustard (toria) are two major oilseed crops of Assam occupying about 2.45 lakh hectares of cultivable land with an average yield of 528 kg/ha which is much lower than the national average of 1152 kg/ha. As this is cultivated under rainfed conditions, inadequate and imbalanced fertilizer use and emergence of multiple-nutrient deficiencies are the major factors responsible for the low productivity of the crops (Tiwari, 2002). Under this circumstance, integration of chemical and organic sources and their management have shown promising results not only in sustaining the productivity but have also proved to be effective in maintaining soil health and enhancing nutrient use efficiency (Thakur *et al*., 2011).

In India, it is the second most important edible oilseed after groundnut sharing 27.8% of India's oilseed economy. In terms of acreage, oilseeds occupy 14.1% and rapeseed-mustard alone occupies 3% of the total cropped area in the country. The global production of rapeseed-mustard and its oil is 38-42 million tonnes and 12–14 million tonnes, respectively. India produces around 6.70 million tonnes of rapeseed-mustard next to China (11-12 m.t) and EU (10–13 m.t) with significant contribution in the world rapeseed mustard industry (Shekhawat *et al.,* 2012).

Now a days, the fertilizer requirements are increasing due to adoption of new high yielding hybrids in intensive cultivation. Therefore, to maintain crop productivity, the use of chemical fertilizers in balanced quantity is important. But looking into the continuous increasing prices of fertilizers, it becomes necessary to minimize the expenses of fertilizers by using alternative sources like vermicompost, FYM, crop residues, green manuring for sustaining the crop yields and soil fertility. These practices not only increase the crop yield but also improve the physico-chemical properties of soil. The long term integrated application of chemical fertilizers with organic manures improves soil physical and chemical properties and soil fertility and crop yields. When integrated nutrient management through chemical fertilizers and different organic sources are applied on a long term basis, they show a beneficial impact on soil quality (Swarup, 2010).

Therefore, the present investigation was carried out to find out the effect of integrated nutrient management on sustaining toria productivity, physical and chemical properties of soil and to identify the most suitable nutrient management practice under rainfed upland condition.

Materials and Methods

The experiment was conducted at the experimental field of All India Coordinated Research Project for Dryland Agriculture at Biswanath College of Agriculture, Biswanath Chariali, Assam (Latitude: 26°84′ N Longitude: 93°13′ E Altitude: 86.7 m) during 2010-11 to 2014-15. The experimental site is located at 26°84′ N and 93°13′ E and 86.7 m altitude. The climate is hot and humid tropical with a mean annual rainfall 1989.4 mm. The mean annual temperature is 22.6°C. The mean maximum temperature 28.0°C and mean minimum temperature is 17.2 °C. The mean annual PET is 1186.6 mm.

Initial (2010) soil characteristics of the experimental field*

Characteristics	0-15 cm depth
Textural class	Sandy Loam
pH	5.05
Organic Carbon	0.53 %
Available Nitrogen	385.73 kg/ha
Available Phosphorus	12.33 kg/ha
Available Potassium	148.08 kg/ha

*Initial soil was collected and analysed just before starting the experiment in 2010.

The North Bank Plains Zone comprise of Darrang, Udalguri, Sonitpur, Lakhimpur and Dhemaji districts. The Zone is characterized by recent and old alluvium soil with sandy to loamy and clay texture and slightly to moderately acidic soil reaction with low CEC. The annual rainfall ranges between 1000 to 2325 mm and relative humidity between 50 to 80%. The temperature ranges from 5 to 37 degree Celsius. The moisture regime in the zone is udic and soil are imperfectly drained to well drained.

The experiment was conducted in Simple Randomized Block Design with eleven treatments replicated three times involving a combination of organic sources and inorganic fertilizers. Treatment combinations were T_1: Control, T_2: 100% Recommended dose of fertilizer (RDF), T_3: 75% RDF + 3 t/ha vermicompost, T_4: 75% RDF + 5 t/ha vermicompost, T_5: 75% RDF + i*n situ Sesbania aculeata*, T_6: 50% RDF + 3 t/ha vermicompost, T_7: 50% RDF + 5 t/ha vermicompost, T_8: 50% RDF + i*n situ Sesbania aculeata,* T_9: 3 t/ha vermicompost, T_{10}: 5 t/ha vermicompost and T_{11}: i*n situ Sesbania aculeata.* The details of date of sowing, harvest of crop and crop duration are given in Table 6. Recommended package of practices were adopted for toria.

The Rain Water Use Efficiency (RWUE) was calculated by dividing the grain yield (kg/ha) to cumulative rainfall (mm) from sowing to harvest. RWUE (kg/ha/mm) indicates yield attained by a treatment per millimeter of rain water received during the cropping period. Since there is no irrigation to the crop other than rain water, RWUE would indicate the water productivity or water use efficiency of a treatment under rainfed condition. The soil available nutrient status viz. N, P_2O_5, K_2O, Organic carbon and pH were analyzed using standard laboratory procedures.

Results and Discussion

Effect on Growth and Yield Attributes

Growth and yield attributes viz. plant population m^{-2}, plant height, pods/plant, 100 seed weight and days to 50% flowering were influenced by various treatments. The pooled data indicated that the plant population and siliqua/plant was maximum under 75% RDF and 5 t/ha vermicompost (Table 1). From the pooled data it was observed that plant height differed significantly amongst treatments and recorded maximum value of 103 cm in T_3 (75% RDF + 3 t/ha vermicompost), it was at par with T_4 (75% RDF + 5 t/ha vermicompost) and T_7 (50% RDF + 5 t/ha vermicompost). Highest siliqua per plant was registered in T_4 (105/plant) which was significantly superior over rest of the treatments. Hundred

Table 1 : Growth and yield attributes as influenced by different treatment (five years pooled data, 2010-11 to 2014-15)

Treatment	Plant population m^{-2}	Days to 50% flowering	Plant height (cm)	Siliqua/plant	100 seed weight (g)
T_1: Control	64	39	84	66	1.98
T_2: RDF (100%)	66	38	87	79	2.04
T_3: 75% RDF + 3 t ha^{-1} VC*	69	38	103	85	2.25
T_4: 75% RDF + 5 t ha^{-1} VC	71	37	101	98	2.26
T_5: 75% RDF + i*n situ S. aculeata*	67	37	91	105	2.12
T_6: 50% RDF + 3 t ha^{-1} VC	68	38	94	77	2.17
T_7: 50% RDF + 5 t ha^{-1} VC	68	38	98	78	2.04
T_8: 50% RDF + i*n situ S. aculeata*	66	37	89	84	2.13
T_9: 3 t ha^{-1} VC	65	37	86	72	2.11
T_{10}: 5 t ha^{-1} VC	67	38	87	73	2.23
T_{11}: i*n situ Sesbania aculeata*	65	38	85	71	2.06
CD (P=0.05)	2.24	NS	5.11	4.52	NS

*VC = Vermicompost

Table 2 : Grain yield an straw yield (q/ha) as influenced by various treatments

Treatment	Grain yield (q/ha)						Stover yield (q/ha)					
	2010-11	2011-12	2012-13	2013-14	2014-15	Pooled mean	2010-11	2011-12	2012-13	2013-14	2014-15	Pooled mean
T_1: Control	4.50	2.93	2.76	2.54	5.12	3.57	10.14	5.89	5.06	5.22	12.35	7.73
T_2: RDF (100%)	8.75	5.98	5.37	4.98	7.46	6.51	17.52	12.05	11.34	10.21	18.24	13.87
T_3: 75% RDF + 3 t/ha VC*	10.13	6.34	5.85	5.28	11.45	7.81	22.06	13.14	12.77	11.45	25.31	16.95
T_4: 75% RDF + 5 t/ha VC	10.50	6.50	6.37	6.17	11.63	8.23	20.44	13.20	12.98	12.76	26.23	17.12
T_5: 75% RDF + *in situ S. aculeata*	9.88	5.45	5.19	4.23	10.25	7.00	20.19	10.99	10.29	9.78	23.15	14.88
T_6: 50% RDF + 3 t/ha VC	7.94	4.70	4.64	4.51	10.53	6.46	14.56	9.52	9.20	9.97	23.87	13.42
T_7: 50% RDF + 5 t/ha VC	7.63	4.75	4.52	4.62	10.68	6.44	17.06	9.48	8.90	8.79	24.11	13.67
T_8: 50% RDF + *in situ S. aculeata*	7.50	4.68	4.23	4.18	9.16	5.95	15.81	9.46	8.37	8.26	20.32	12.44
T_9: 3 t/ha VC	4.75	4.05	4.10	3.76	5.88	4.51	10.12	8.33	8.16	7.54	14.16	9.66
T_{10}: 5 t/ha VC	5.50	4.43	4.14	3.84	6.17	4.82	14.38	8.96	8.21	7.76	15.55	10.97
T_{11}: *in situ Sesbania aculeata*	5.00	4.12	4.07	3.22	6.10	4.50	14.06	8.35	8.05	7.12	15.19	10.55
CD (P=0.05)	2.13	1.44	1.42	1.38	2.17	1.71	2.45	1.20	1.18	1.14	2.38	1.67

*VC=Vermicompost

seed weight was found non significant which may be due to the fact that test weight cannot be changed easily by treatments within a short span of time. The higher values of growth and yield attributes due to integrated nutrient management was also recorded in mustard (Parihar *et al.,* 2014) and rice (Gautam *et al.,* 2013)

Effect of Integrated Nutrient Management on Toria yield

The grain yield of toria was significantly affected due to the various nutrient management treatments during all the years of experimentation (Table 2). The highest grain yield of toria was obtained with application of 75% RDF + vermicompost @ 5 t/ha which was superior over the rest of the treatments during the year 2010-11 to 2014-15. However, during the year from 2010-11 to 2014-15 in pooled mean the application of 75% RDF + vermicompost @ 3 t/ha was on par with this treatment. The application of 100% RDF through chemical fertilizers was on par with the integrated use of 75% RDF + vermicompost @ 5 t/ha during the first four years of study, while during fifth year and in pooled results, the difference was significant. This clearly indicated that the balanced nutrition through only chemical fertilizers did not sustain the grain yield of toria on long run compared with conjunctive use of organic and inorganic fertilizers. Benefits accruing from the integrated use of chemical fertilizers with organics might be attributed to better conservation of moisture, nutrient supply through incorporation of organics along with conducive physical environment leading to better root activity and higher nutrient absorption, which resulted in better plant growth leading to superior yield attributes responsible for high yield. The results with significant effects of organics and chemical fertilizers are in agreement with Srinivasa Rao (2011) and Basak *et al*. (2012). The pooled results indicated that the application of 75% RDF + vermicompost @ 5 t/ha recorded significantly higher grain yield (8.23 q/ha) which was at par with the application of 75% RDF + vermicompost @ 3 t/ha. The lowest grain yield (3.57 q/ha) was recorded in the control treatment. The increased yield may be attributed to improvement in yield attributing characters, viz. plant height, siliqua per plant and test weight of seed. Similar findings were also reported by Patel *et al.* (1994).

Rain water use efficiency

The RWUE was higher with 75% RDF and 5 t/ha vermicompost as compared to control treatment (Table 4) during the 2010-11 to 2014-2015 and also when pooled. The pooled data recorded the highest RWUE of 10.50 kg/ha/mm in T_4 which was almost 50% higher over the control treatment. This indicates better use of rainwater under this treatment as compared with the rest of the treatments. This was followed by 75% RDF and 3 t/ha vermicompost. The higher RWUE attained might be due better resource use-efficiency by the crop (Dhadge *et al.,* 2014).

Soil Fertility

The soil organic C, available N, P and K (Table 3) were significantly influenced due to different treatments after harvesting of toria. The application of 75% recommended dose of fertilizer along with 5 t/ha vermicompost recorded significantly higher soil organic carbon content (0.89%) which was at par with T_3 treatment i.e. 75% recommended dose of fertilizer + 3 t/ha vermicompost. The least soil organic carbon

Table 3 : Effect of integrated nutrient management on soil properties (five years pooled data, 2010-11 to 2014-15)

Treatments	Bulk Density (Mg/cu m)	pH	Organic Carbon (%)	Available nutrients (kg/ha)		
				N	P_2O_5	K_2O
T_1: Control	1.31	4.87	0.55	295.25	25.57	145.29
T_2: RDF (100%)	1.18	5.05	0.71	429.22	49.17	192.99
T_3: 75% RDF + 3 t ha^{-1} VC*	1.02	5.56	0.82	450.25	51.05	231.08
T_4: 75% RDF + 5 t ha^{-1} VC	0.97	5.87	0.89	454.23	52.58	234.95
T_5: 75% RDF + i*n situ S. aculeata*	1.11	5.75	0.75	427.29	49.23	197.27
T_6: 50% RDF + 3 t ha^{-1} VC	1.12	5.32	0.88	428.31	49.46	197.41
T_7: 50% RDF + 5 t ha^{-1} VC	1.05	5.45	0.81	431.63	50.43	199.36
T_8: 50% RDF + i*n situ S. aculeata*	1.03	5.24	0.83	415.83	46.57	194.15
T_9: 3 t ha^{-1} VC	1.15	5.31	0.86	413.60	41.13	188.89
T_{10}: 5 t ha^{-1} VC	1.12	5.42	0.87	412.69	43.54	189.63
T_{11}: i*n situ Sesbania aculeata*	1.10	5.22	0.69	416.68	41.19	189.41
CD (P=0.05)	0.28	0.95	0.32	30.45	11.21	15.48

*VC=Vermicompost

Table 4 : Pooled rainwater use efficiency (RWUE) of toria

Treatment	Rainwater use efficiency (RWUE kg/ha/mm)					
	2010-11	2011-12	2012-13	2013-14	2014-15	Pooled mean
T_1: Control	8.75	8.83	13.80	14.22	9.06	4.50
T_2: RDF (100%)	17.02	18.01	26.85	27.66	13.20	8.75
T_3: 75% RDF + 3 t ha^{-1} VC*	19.71	19.09	29.25	29.33	20.27	10.13
T_4: 75% RDF + 5 t ha^{-1} VC	20.43	19.58	31.85	34.27	20.58	10.50
T_5: 75% RDF + i*n situ S. aculeata*	19.22	16.42	25.95	23.50	18.14	9.88
T_6: 50% RDF + 3 t ha^{-1} VC	15.45	14.16	23.20	25.05	18.64	7.94
T_7: 50% RDF + 5 t ha^{-1} VC	14.84	14.31	22.60	25.66	18.90	7.63
T_8: 50% RDF + i*n situ S. aculeata*	14.60	14.09	21.15	23.22	16.21	7.50
T_9: 3 t ha^{-1} VC	9.24	12.20	20.50	20.88	10.41	4.75
T_{10}: 5 t ha^{-1} VC	10.70	13.34	20.70	21.33	10.92	5.50
T_{11}: i*n situ Sesbania aculeata*	9.73	12.41	35.20	17.88	10.80	5.00

*Vc=Vermicompost

Table 5 : Pooled gross monetary returns, total cost of cultivation (₹/ha), net returns (₹/ha), B-C ratio as influenced by different treatments (2010-11 to 2014-15)

Treatment	Gross returns (₹/ha)	Total cost of cultivation (₹/ha)	Net returns (₹/ha)	B-C ratio
	Pooled mean	Pooled mean	Pooled mean	Pooled mean
T_1: Control	10577	8546	2031	1.24
T_2: RDF (100%)	17863	9825	8038	1.82
T_3: 75% RDF + 3 t ha^{-1} VC*	22682	11573	11109	1.96
T_4: 75% RDF + 5 t ha^{-1} VC	25539	12248	13291	2.09
T_5: 75% RDF + i*n situ S. aculeata*	18295	9556	9020	1.91
T_6: 50% RDF + 3 t ha^{-1} VC	19576	10159	9417	1.92
T_7: 50% RDF + 5 t ha^{-1} VC	19857	10893	8964	1.82
T_8: 50% RDF + i*n situ S. aculeata*	17446	9664	7782	1.81
T_9: 3 t ha^{-1} VC	12269	8785	3484	1.28
T_{10}: 5 t ha^{-1} VC	13684	9327	4357	1.47
T_{11}: i*n situ Sesbania aculeata*	11467	8936	2531	1.28

*Vc=Vermicompost

Table 6 : Dates of sowing, harvest of crop, crop duration, cumulative rainfall (mm) and cumulative rainy days at experimental site

Year	Date of sowing	Date of harvest	Crop duration (days)	Cumulative rainfall (mm)	Cumulative rainy days
2010-11	28/10/2010	26/01/2011	91	51.4	05
2011-12	09/11/2011	06/02/2012	90	33.2	05
2012-13	26/11/2012	28/02/2013	95	20.0	04
2013-14	21/11/2013	21/02/2014	93	18.0	03
2014-15	25/11/2014	27/02/2015	95	56.5	05

content (0.55%) was recorded in the control treatment. However, the maximum values of soil available N (454.23 kg/ha), P_2O_5 (52.58 kg/ha) and K_2O (234.95 kg/ha) were recorded under 75% recommended dose of fertilizer + 5 t/ha vermicompost which were signifacantly superior over control. The favorable soil conditions might have helped in the mineralization of soil N leading to its higher build-up in these treatments (Urkurkar *et al*., 2010). An increase in available P might be due to release of organic acids viz. chiefly maleic and citric acid on decomposition of organic manures which helps in solubulization of unavailable P (Singh *et al.,* 2011). An increase in available K due to the addition of organic manures may be ascribed to the reduction of K-fixation and release of K due to interaction of organic matter with clays, besides the direct K addition to the soil (Urkurkar *et al*., 2010; Subehia and Sepehya 2012). Similar beneficial effects of organic sources as well as the integration of different sources of nutrients on soil fertility were also reported by Reddy (2005), Akbari *et al*. (2011), Basak *et al*., 2012 and Tamboli *et al.* (2014)

Economics

Application of 75% recommended dose of fertilizer and vermicompost @ 5 t/ha (T_4) resulted in highest gross (₹ 25539/ ha) and net returns (₹ 13291/ha) with 2.09 benefit:cost ratio (Table 5). This was followed by T_3 treatment (75% recommended dose of fertilizer and vermicompost @ 3 t/ha). Similar results were reported earlier by Singh and Singh (2012).

Conclusion

From the results, it may be concluded that the maximum grain and straw yield of toria, net profit, B: C ratio was obtained in rainfed upland condition of NBPZ of Assam with integrated use of 75% recommended dose of fertilizer + 5 tonnes vermicompost per hectare (T_4). The status of organic carbon, available N, P and K in soil improved considerably after harvest of toria crop under the treatment T_4.

Acknowledgements

The authors are highly grateful to Indian Council of Agricultural Research, New Delhi and All India Coordinated Research for Dryland Agriculture, CRIDA, Hyderabad for providing financial support for conducting the present study. The authors also thankful to the Honorable Vice Chancellor, AAU, Jorhat; Director of Research (Agri), AAU, Jorhat and Dr. T. C. Baruah, Dean, BN College of Agriculture, Biswanath Chariali, Sonitpur for providing facilities to carry out the investigation.

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Received: November 2015; Accepted: April 2016