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Growth and yield performance of late sown Toria (*Brassica rapa* subsp. *Toria*) under integrated nutrient management practices in Assam

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Abstract

A field experiment was carried out to quantify the effect of integrated nutrient management practices on late sown *Toria* during *Rabi* seasons of 2017-18 and 2018-19. The experiment was laid out in randomized block design with ten treatments *viz.,* 100% (40-35-15 kg N-P_2O_5-K_2O/ha + 10 kg borax/ha) and 75% RDF along with a successive combination of vermicompost (@ 2 t/ha), sulphur (20 kg/ha), zinc (4 kg/ha and biofertilizers (*Azotobacter* and *Azospirillum*). The result revealed that application of 100% RDF + vermicompost @ 2 t/ha + 20 kg S/ha + 4 kg Zn/ha + seed treatment with biofertilizer consortia significantly increased the plant growth parameters and yield attributing characters in both the years as compared to other treatments. The same treatment also registered the highest seed yield (945 and 1025 kg/ha) and stover yield (2237 and 2292 kg/ha) during 2017-18 and 2018-19, respectively. Where as in both years the highest oil content was obtained in treatment having 75% RDF + vermicompost @ 2 t/ha + 20 kg S/ha + 4 kg Zn/ha + seed treatment with biofertilizer consortia.

Keywords*: Growth, integrated nutrient management, Toria, yield*

Introduction

Rapeseed-mustard is a major oilseed crop in India and around the world. India ranked fourth in rapeseed and mustard production after Canada, China and the European Union with 17.19% area and 8.54% production in the world (Anonymous, 2019). It is the only oilseed crop which is being extensively cultivated by the farmers during *Rabi* season in Assam. The annual production of rapeseed-mustard was about 1.85 lakh tonnes with productivity of 639 kg/ha and it occupying an area of about 2.90 lakh hectares (Anonymous, 2018). In Assam, its productivity is very much less as compared to national productivity and one of the reasons may be due to improper fertilization. So, the integration of organic, inorganic and biofertilizers could be a potential source to overcome this huge gap in productivity. Integrated nutrient management maintains the soil fertility and plant nutrient supply in optimum amounts. It reduces the amount of inorganic fertilizers and creates favorable soil condition and healthy environment and sustains the desired crop productivity for the long term by balancing soil nutrients. Growth attributes *viz.* plant height, total dry matter accumulation, leaf area index of mustard (*B. juncea*) were recorded significantly higher when the recommended dose of fertilizers (RDF) was applied along with farm yard manure, Zn and seed treatment with *Azotobacter* (Singh and Pal, 2011). Integration of RDF and vermicompost also resulted in better yield attributes and grain yield in Indian mustard (Singh *et al.,* 2014). Hence, the application of organic and inorganic nutrient with biofertilizer could be beneficial for sustaining the productivity of the crop under late sown condition. Therefore, the present experiment was conducted to study the influence of integrated nutrient management on growth, yield and quality of late sown *Toria* in Assam.

Materials and Methods

An experiment was carried out at Instructional-cum-Research Farm of Assam Agricultural University, Jorhat, Assam during the *Rabi* season of 2017-18 and 2018-19. In both the years, before the experiment, the land was occupied by *sali* rice during the *Kharif* season which was harvested in the last week of November. The soil of the experimental site was sandy loam in texture, acidic in reaction (pH 5.2), medium in organic carbon (0.51%), available N (315.5 kg/ha), available K_2O (137.5 kg/ha) and available Zn (0.79 mg/kg) while low in available P_2O_5 (17.8 kg/ha), available S (16.1 kg/ha) and available B (0.21 mg/kg) at the start of the study. The total rainfall received during the *Rabi* seasons for both the years were 79.6 and 99.4 mm respectively. The experiment was laid out in randomized block design and replicated thrice and consisted of ten treatments. The treatments were 100% recommended dose of fertilizer (RDF) (40-35-15 kg N-P_2O_5-

K_2O/ha + 10 kg borax/ha) (T_1), T_1 + vermicompost @ 2 t/ ha (T_2), T_2 + 20 kg S/ha (T_3), T_3 + 4 kg Zn/ha (T_4), T_4 + seed treatment with biofertilizer consortia (T_5), 75% RDF (T_6), T_6 + vermicompost @ 2 t/ ha (T_7), T_7 + 20 kg S/ha (T_8), T_8 + 4 kg Zn/ha (T_9) and T_9 + seed treatment with biofertilizer consortia (T_{10}). As per treatment full dose of all the fertilizers and vermicompost and half dose of urea was applied by broadcasting and incorporated into the soil one day before sowing. The remaining half dose of N was applied 20 days after sowing along with thinning operation. For the treatment T_5 and T_{10}, seeds were treated with biofertilizer consortia containing *Azotobacter* and *Azospirillum* @ 10 g/kg of seeds. Treated seeds were allowed to dry for the whole night. Toria variety 'Jeuti' was sown in 30 cm rows on 7th December 2017 and 11th December 2018. Crops were harvested on 6th March 2018 and 8th March 2019, respectively. Growth attributes, yield attributes and yield, were recorded by following the standard procedures. Seed oil content was determined with the help of soxhlet extraction unit as per the method described by AOAC (1960). The results were analyzed using a standard statistical procedure for randomized block design. The critical difference at the 5% probability level was calculated when the F value was observed significant.

Results and Discussion

Plant growth parameters

Significant variation in growth characteristics of Toria was recorded by the application of various INM treatments during both the years (Table 1). The maximum values of growth parameters were recorded with 100% RDF with other inorganic, organic and biofertilizer as compared to other treatments during both the years. Plant height, number of leaves per plant, leaf area index, dry matter production per plant and number of primary and secondary branches per plant were found to be significantly higher due to the application of 100% RDF + 2 t vermicompost/ha + 20 kg S/ha + 4 kg Zn/ha + seed treatment with biofertilizer consortia (T_5). The addition of nutrient elements from inorganic, organic and biofertilizer might have resulted in better availability of nutrients leading to high accumulation of net photosynthates and better proliferation of roots and mobilization of plant nutrients in a more efficient way that seems to have promoted growth parameters by way of active cell division and elongation. Higher growth characters of Indian mustard were recorded when N, P and K were integrated with vermicompost 2 t/ha + sulphur 40 kg/ha + zinc sulphate 25 kg/ha + boron 1 kg/ha and seed inoculation with *Azotobacter* @ 10 g/kg seed (Kumar *et al.*, 2016).

Yield attributes

The yield attributing characters of *Toria* were influenced significantly by treatment comprised of integration of various nutrients in both the years. Data presented in Table 2 revealed that application of 100% RDF + 2 t vermicompost/ha + 20 kg S/ha + 4 kg Zn/ha + seed treatment with biofertilizer consortia (T_5), improved various yield attributing characters *viz.*, siliqua length (5.57-5.63 cm), number of siliquae per plant (113-118), number of seeds per siliqua (22.6-22.9), as compared to other treatments except for 1000-seed weight which was non-significant. Combined application of 100% RDF + 2 t vermicompost/ha + 20 kg S/ha + 4 kg Zn/ha + seed treatment with biofertilizer consortia, through various sources of inorganic, organic and biofertilizer increased

Table 1: Effect of integrated nutrient management practices on plant growth parameters of late sown *Toria*

Treatment	Plant height (cm)		No. of leaves/ plant (at 60 DAS)		Leaf Area Index (at 60 DAS)		Dry matter production (g/plant)		No. of primary branches		No. of secondary branches	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
T_1	89.0	91.0	7.1	7.3	0.71	0.73	5.4	5.5	4.7	4.8	4.8	5.1
T_2	91.2	92.4	7.3	7.7	0.75	0.77	5.8	5.9	4.7	4.8	4.8	5.0
T_3	93.9	95.5	7.9	8.1	0.78	0.81	6.1	6.3	4.9	5.0	5.4	5.5
T_4	101.0	102.9	8.3	8.4	0.84	0.86	6.3	6.6	5.1	5.4	5.6	5.9
T_5	107.2	107.8	8.8	9.1	0.91	0.93	7.0	7.3	6.0	6.1	6.2	6.4
T_6	81.8	84.7	6.6	7.0	0.68	0.68	5.0	5.1	4.0	4.1	4.3	4.5
T_7	86.1	90.3	7.1	7.3	0.67	0.71	5.3	5.3	4.2	4.4	4.6	4.6
T_8	89.9	92.2	7.5	7.8	0.71	0.74	5.6	5.6	4.4	4.7	4.9	4.9
T_9	94.0	95.3	7.6	7.9	0.73	0.76	5.8	5.8	4.6	4.8	4.9	5.1
T_{10}	99.0	100.5	8.1	8.3	0.79	0.84	6.2	6.4	5.0	5.3	5.4	5.6
SEm±	1.8	1.8	0.1	0.1	0.01	0.01	0.08	0.08	0.1	0.1	0.1	0.1
CD (P=0.05)	5.3	5.3.	0.5	0.3	0.03	0.02	0.26	0.23	0.2	0.3	0.3	0.4

Table 2: Effect of integrated nutrient management practices on yield attributes of late sown *Toria*

Treatment	Length of siliqua (cm)		No. of siliquae/ plant		No. of seeds/siliqua		1000-seed weight (g)	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
T_1	4.69	4.83	90.2	92.6	19.3	19.6	2.58	2.58
T_2	4.74	5.00	96.2	98.6	19.8	19.9	2.59	2.59
T_3	4.82	5.05	99.2	99.5	19.9	19.9	2.59	2.61
T_4	5.20	5.27	102.5	103.7	21.9	21.7	2.62	2.63
T_5	5.57	5.63	113.1	117.6	22.6	22.9	2.64	2.64
T_6	4.25	4.40	66.6	69.2	17.8	17.6	2.52	2.54
T_7	4.67	4.62	75.3	76.5	18.4	19.7	2.53	2.55
T_8	4.70	4.77	84.8	86.7	18.8	19.7	2.55	2.58
T_9	4.77	4.83	89.1	90.7	19.4	19.8	2.58	2.59
T_{10}	5.07	5.17	97.5	100.0	21.4	20.0	2.60	2.61
SEm±	0.11	0.06	1.6	1.2	0.2	0.5	0.05	0.05
CD (P=0.05)	0.34	0.20	4.8	3.7	0.4	1.6	NS	NS

the yield attributes which was probably due to improvement in the physical and chemical properties of soil that provided a better soil environment for the biological activity and improved microbial population in the soil. And this micro-organism probably fixed the atmospheric nitrogen in the soil and they also released some plant hormones (auxin, gibberellin and cytokinin) and growth-promoting substances that affected plant growth and development by enhancing protoplasmic constituents and accelerated the process of cell-division, cell-elongation and expansion which in turn increased the values of yield attributes.

Increase in number of siliquae/plant, siliqua length, 1000-seed weight, number of seeds/siliqua were also reported by Dutta *et al*. (2009) in *Brassica rapa* due to integrated nutrient management which included inorganic, organic and bio fertilizers.

Seed and stover yields

The seed and stover yields, and harvest index varied significantly due to different INM treatments during both the years as shown in Table 3. Treatment which comprised 100% RDF + 2 t vermicompost/ha + 20 kg S/ha+ 4 kg Zn/ ha + seed treatment with biofertilizer consortia (T_5) gave the highest seed (945 kg/ha in 2017-18 and 1025 kg/ha in 2018-19) and stover yield (2237 kg/ha in 2017-18 and 2292 kg/ha in 2018-19) followed by treatment 100% RDF + 2 t vermicompost/ha + 20 kg S/ha+ 4 kg Zn/ha (T_4). The per cent increase in seed yield with T_5 over T_6 (75% RDF) was to the tune of 67.6 and 75.3 during 2017-18 and 2018-19, respectively. While the per cent increase in stover yield with T_5 over T_6 was 48.5 and 50.1 during 2017-18 and 2018-19, respectively. The harvest index of toria remained non-significant among different integrated nutrient management schedules. The yield is directly dependent on various growth and yield parameters. Increase in seed yield under T_5 treatment was mainly due to increase in yield attributes *viz.*, the higher number of siliquae per plant, seeds per siliqua and 1000-seed weight and their cumulative effect. An integration of inorganic, organic and biofertilizer probably enhanced supply of essential nutrients, their availability and acquisition, mobilization into plant tissues and thus improved growth and yield components and finally yields. Shukla *et al.* (2002) also reported that maximum seed yield and stover yield of Indian mustard with the application of 50 and 100% of the recommended fertilizer rates with FYM @ 10 t/ha and *Azotobacter.* Similar results have also been reported by Meena *et al.* (2021).

Oil content and oil yield

Oil content is typically a characteristic of species, cultivars and their genetic makeup but environmental conditions and nutrition also affect its amount. From the data presented in Table 3, it was observed that the oil content and oil yield varied significantly due to various nutrient management practices. In 2017-18, the highest oil content (38.24%) was recorded in treatment having 75% RDF + 2 t vermicompost/ha + 20 kg S/ha+ 4 kg Zn/ha + seed treatment with biofertilizer consortia (T_{10}) which was at par with T_4, T_5, T_7, T_8 and T_9. In 2018-19, the highest oil content (38.73%) was also found in T_{10} which was at par with T_5 and T_9. The decrease of oil content with increasing RDF from 75% to 100% RDF could be due to increasing availability of nitrogen which increased the proportion of proteinous substance in seed and hence oil content was a low but integrated application of 75% RDF with vermicompost, sulphur, zinc and seed inoculation with biofertilizer consortia resulted in the highest oil content. The increase in oil content under INM treatment might be attributed to increasing the availability of S and Zn that

Table 3: Effect of integrated nutrient management practices on seed and oil yield parameters of late sown *Toria*

Treatment	Seed yield (kg/ha)		Stover yield (kg/ha)		Harvest index (%)		Oil content (%)		Oil yield (kg/ha)	
	2017-18	2018-19	2017-18	2017-18	2017-18	2017-18	2017-18	2018-19	2017-18	2018-19
T_1	665	694	1659	1694	28.6	29.0	32.0	32.4	213	224
T_2	756	789	1809	1838	29.5	30.0	33.6	34.0	254	268
T_3	811	835	1907	1935	29.8	30.1	34.7	35.0	282	298
T_4	864	930	2127	2185	28.9	29.9	35.9	36.0	310	335
T_5	945	1025	2237	2292	29.7	30.9	36.9	37.1	348	380
T_6	564	585	1507	1527	27.3	27.7	34.3	34.6	193	202
T_7	668	687	1603	1623	29.4	29.7	34.9	35.2	234	241
T_8	722	744	1729	1743	29.4	29.9	35.7	36.0	257	268
T_9	761	787	1866	1894	29.0	29.4	37.1	37.6	283	295
T_{10}	821	858	2018	2085	28.9	29.1	38.2	38.7	314	332
SEm±	27.2	30.3	36.8	33.8	0.1	0.1	1.15	0.83	12.1	11.3
CD (P=0.05)	80.8	90.2	109.4	100.3	NS	NS	3.41	2.48	36.0	33.5

involved in increased conversion of primary fatty acids metabolites to the end products of fatty acids, as reported by Tripathi *et al.* (2010). These results were also similar to that of Nagdive *et al.* (2007) where they observed that nutrient management levels significantly influenced the oil content of mustard. The oil yield was recorded the highest in treatment T_5 (100% RDF + vermicompost @ 2 t/ha + 20 kg S/ha + 4 kg Zn/ha + seed treatment with biofertilizers). Singh *et al.* (2017) reported that treatment containing 100% RDF of NPK + FYM@ 5 t/ha + S @ 40 kg/ha recorded significantly higher oil yield (6.72 q/ha) in Indian mustard.

Conclusion

The combined application of 100% RDF + vermicompost @ 2 t/ha + 20 kg S/ha + 4 kg Zn/ha + seed treatment with biofertilizer consortia substantially enhanced the productivity and oil yields of the *toria*. Thus, integrated nutrient management practices could be a strategy to enhance the productivity and profitability of *toria* growers in Assam, in addition to build-up of soil fertility and sustainability in long-run.

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