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Nutrient content, uptake and oil content of rapeseed as influenced by reduced tillage, mulching and INM practices

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Abstract
A field study was carried out to evaluate the effect of reduced tillage, mulching and INM practices on nutrient content, nutrient uptake and oil content of rapeseed under rainfed condition at Assam Agricultural University, Jorhat, Assam during the *rabi* seasons of 2016-17 and 2017-18. The experiment was laid out in a split-plot design with three replications. The main-plot treatments comprised of two tillage practices (P_1: conventional tillage and P_2: reduced tillage) and two mulching practices (M_1: No mulching and M_2: mulching with paddy straw) and the sub-plot treatments comprised of four nutrient management practices *viz.*, N_1:100% RDF (Recommended Dose of Fertilizer), N_2: 50 % RDN (Recommended Dose of Nitrogen) through chemical fertilizer + 50% N through FYM, N_3: 50% RDN through chemical fertilizer + 50% N through Vermicompost and N_4: 50% RDN through chemical fertilizer + 50% N through Enriched Compost. The treatment receiving 50 per cent recommended dose of nitrogen through chemical fertilizer and rest 50 per cent through FYM (N_2) recorded significantly highest N, P and K contents in seed and stover. Reduced tillage (P_2) brought an average of 7.4%, 8.0% and 7.8% higher uptake of N, P and K, respectively over conventional tillage (P_1). Similarly, mulching (M_2) brought 12.0%, 12.9% and 11.8% higher N, P and K uptake, respectively and significantly higher seed oil content over no-mulching (M_1). Integrated use of 50 per cent recommended dose of nitrogen through chemical fertilizer and rest 50 per cent through FYM (N_2) resulted an average of 18.4%, 18.5% and 16.5% higher N, P and K uptake, respectively and significantly higher seed oil content over 100% RDF (N_1).

Keywords: Reduced tillage, INM, paddy straw, nutrient content, nutrient uptake, oil content

Introduction
Rapeseed and mustard require relatively cool temperature for satisfactory growth and productivity as it is a crop of tropical as well as temperate zones. Because of its shorter duration and higher adaptability to different soil types and diverse agro-climatic regions, it has been a promising important oilseed crop. Rapeseed and mustard contribute nearly one-third of the oil produced in India, which makes it the country's key edible oilseed crop. India occupies first place in the area of rapeseed-mustard with 6.32 mha, while it is next to China in production contributing 7.39 mt to the total global production (Anonymous, 2016a) [2]. It is a short duration crop grown mostly as winter season crop in Assam, Bihar, West Bengal and Odisha and also in limited areas of the eastern part of Uttar Pradesh. Among the various oilseed crops in Assam, rapeseed-mustard occupies the first position with about 90 per cent area and production of the state. In Assam, rapeseed-mustard is the only popular oilseed crop grown on commercial basis, which occupies an area of 2.86 lakh ha accounting 1.99 lakh tones of production and productivity being 698 kg/ha (Anonymous, 2016b) [3], which is much lower than world average of 1830 kg/ha (Anonymous, 2013) [4] as well as all India average of 1170 kg/ha.

Since these crops are cultivated mainly in the rainfed regions, the productivity of this crop depends mainly on the amount of rainfall and its distribution pattern as well as residual soil moisture during the crop growing season. Cultivation of rapeseed-mustard becomes less remunerative to the farmers under marginal resource situations, which results in a big gap between requirement and production of rapeseed-mustard in India. Therefore an integrated approach of soil, plant and nutrient management with effective management of available natural resources can be a key in stabilizing and increasing the production and productivity of rapeseed-mustard.

The optimum sowing time of rapeseed-mustard in Assam is the middle of October to middle of November. Even though the *kharif* rice vacates the land in time, excess soil moisture at the time of rice harvesting does not permit proper field preparation and timely sowing of rapeseed-

mustard. Furthermore, standing rice stubbles also obstruct normal tillage operation for the succeeding crop immediately after rice harvest resulting in a delay in sowing of *toria*, which results in uneven germination leading to poor yield. Under such circumstances, adoption of minimum tillage after cutting rice stubbles at the base and using it as mulch to conserve the residual soil moisture could be a good option (Chandrasekharan *et al.*, 1996) [8]. Integrated nutrient management has always been found to be a better option in intensive cropping system compared to chemical-based fertilizer management practices. Additionally, the organic component of INM also helps in soil moisture conservation by increasing the water holding capacity of the soil and moderating soil temperature. Keeping above facts in view, a field experiment was conducted to evaluate the influence of different tillage, mulching and nutrient management practices on nutrient content, nutrient uptake and oil content of late sown *toria* under *sali* rice fallow situation.

Materials and methods

A field study was carried out to evaluate the effect of reduced tillage, mulching and INM practices nutrient content, uptake and oil content of rapeseed under rainfed condition during the *rabi* seasons of 2016-17 and 2017-18 at Assam Agricultural University, Jorhat, Assam. The soil of the experimental site was sandy loam in texture, acidic in reaction (pH 5.5 and 5.4), medium in organic carbon (0.70% and 0.68%), medium in available N (301.06 kg/ha and 282.24 kg/ha), low in available P_2O_5 (21.03 kg/ha and 19.24 kg/ha) and medium in available K_2O (161.28 kg/ha and 154.56 kg/ha). The experiment was laid out in a split plot design with three replications and sixteen treatments. The treatments comprised of two tillage practices (P_1:Conventional tillage and P_2:Reduced tillage) and two mulching practices (M_1:No mulching and M_2: Mulching with paddy straw) in the main plot and four nutrient management practices *viz.*, N_1:100 % Recommended Dose of NPK *i.e.* RDF (40, 35 and 15 kg/ha N, P_2O_5 and K_2O) through chemical fertilizer, N_2: 50 % Recommended Dose of Nitrogen (RDN) through chemical fertilizer + 50% N through FYM, N_3: 50 % RDN through chemical fertilizer + 50% N through Vermicompost and N_4: 50 % RDN through chemical fertilizer + 50% N through Enriched Compost in sub plots. The conventional tillage plots were first ploughed by tractor-drawn disc plough after harvest of *kharif* rice, subsequently cross harrowed by disc harrow. The stubbles and weeds were removed and the final land preparation was done by using rotovator. The reduced tillage plots were initially ploughed by tractor-drawn disc plough and then cross ploughed by power tiller with stubble incorporation. In the nutrient management treatments, half of the nitrogen and full doses of phosphorus (P_2O_5), potassium (K_2O) and organic manures as per treatment were applied uniformly one day before sowing in the furrows opened for the sowing of seeds and were incorporated into the soil uniformly by hoeing. The remaining half of the nitrogen was top dressed after weeding operation. The late sown *toria* var. 'JT-90-1' (*Jeuti*) was sown in the second week of December with a seed rate of 13 kg/ha (15.6 g/plot) and spacing of 25 cm row to row and 5-7 cm plant to plant by placing the seeds in the furrows of 4-5 cm depth. One weeding was done with garden hoe at 22 days after sowing and the infestation of mustard aphid was controlled effectively by spraying Chlorpyriphos 20 EC at the rate of 2 ml/l twice at ten days interval.

The crop was harvested in the first week of March and seed and stover yields per hectare were worked out on the basis of yield records in each plot. The plant samples collected from each plot at maturity stage were dried in oven at 60^0C for 48 hours and the ground samples were analysed for N, P and K contents by Kjeldahl method, Vanadomolybdate method and flame photometric method, respectively. The nutrient uptake by seed and stover were calculated by standard formula and then total uptake was calculated by adding the uptakes in seeds and stover. Seed oil content was determined with the help of "Soc-Plus" apparatus as per the method described by AOAC (1960) [5] by taking 5g seed samples from each plot. The analyses of the results were done using standard statistical procedure given by Panse and Sukhatme (1985) [13].

Results and Discussion

Effect on nutrient (N, P and K) content and uptake

The influence of tillage treatments on seed and stover N, P and K content was found to be non significant (Table 1 and Table 2). However, the treatment reduced tillage (P_2) showed comparatively higher values for N, P and K content compared to that of conventional tillage during both the years of study. On the other hand, reduced tillage brought significantly higher uptake of N, P and K of late sown *toria* than conventional tillage during both the years of study (Table 3). On an average, there was an increase of 7.4, 8.0 and 7.8 per cent of N, P and K uptake, respectively in reduced tillage over conventional tillage. This might be attributed to better availability and distribution of plant nutrients due to relatively better soil moisture regimes and slower organic matter decomposition under reduced tillage systems. Yadav *et al.* (2016) [21] reported the minimum value for NPK uptake in conventional tillage and maximum value in zero tillage. Malhi and Nyborg (1990) [11] also observed similar results under minimum tillage over conventional tillage.

Table 1: Effect of tillage, mulching and INM practices on nutrient content in seed of late sown *toria*

Treatments	Seed N, P and K content (%)					
	N-content		P-content		K-content	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Tillage (P)						
P_1: Conventional tillage	2.584	2.579	0.533	0.529	0.497	0.491
P_2: Reduced Tillage	2.586	2.583	0.541	0.532	0.507	0.493
S.Em (±)	0.003	0.002	0.004	0.002	0.003	0.001
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Mulching (M)						
M_1: No Mulching	2.580	2.573	0.531	0.528	0.496	0.490
M_2: Mulching with paddy straw	2.591	2.589	0.543	0.533	0.508	0.494
S. Em (±)	0.003	0.002	0.004	0.002	0.003	0.001
CD (P=0.05)	NS	0.007	NS	NS	NS	NS
Nutrient Management(N)						

N_1: 100 % RDF	2.577	2.573	0.531	0.525	0.493	0.486
N_2: 50% RDN +FYM	2.590	2.587	0.541	0.534	0.508	0.497
N_3: 50% RDN +VC	2.588	2.584	0.537	0.531	0.505	0.494
N_4: 50% RDN +EC	2.585	2.580	0.538	0.530	0.502	0.491
S.Em (±)	0.002	0.002	0.002	0.002	0.002	0.002
CD (P=0.05)	0.007	0.006	0.005	0.006	0.007	0.005

Table 2: Effect of tillage, mulching and INM practices on nutrient content in stover of late sown *toria*

Treatments	Stover N, P and K content (%)					
	N-content		P-content		K-content	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Tillage (P)						
P_1: Conventional tillage	0.572	0.565	0.413	0.404	1.177	1.172
P_2: Reduced Tillage	0.576	0.569	0.416	0.407	1.184	1.177
S.Em (±)	0.003	0.001	0.003	0.003	0.003	0.003
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Mulching (M)						
M_1: No Mulching	0.569	0.562	0.409	0.402	1.175	1.170
M_2: Mulching with paddy straw	0.579	0.572	0.420	0.409	1.186	1.179
S. Em (±)	0.003	0.001	0.003	0.003	0.003	0.003
CD (P=0.05)	NS	0.004	NS	NS	NS	NS
Nutrient Management(N)						
N_1: 100 % RDF	0.567	0.557	0.407	0.400	1.173	1.167
N_2: 50% RDN +FYM	0.588	0.575	0.420	0.411	1.185	1.182
N_3: 50% RDN +VC	0.576	0.570	0.417	0.407	1.183	1.176
N_4: 50% RDN +EC	0.575	0.567	0.415	0.405	1.181	1.174
S.Em (±)	0.003	0.002	0.002	0.003	0.002	0.003
CD (P=0.05)	0.008	0.005	0.006	0.009	0.006	0.009

The influence of mulching treatments on P and K content during both the years and N content during the first year of study was found to be non-significant (Table 1 and Table 2). However, the N, P and K content were comparatively higher in mulching with paddy dtraw than no-mulching treatment. The uptake of these nutrents was influenced by the mulching treatments significantly and the higher values of uptake were recorded by the crops grown with paddy straw mulch as compared to that with no mulch (Table 3). On an average, there was an increase of 12, 12.9 and 11.8 per cent of N, P and K uptake, respectively in crops grown with paddy straw mulching over the no-mulching. This might be due to relatively higher moisture and thermal regimes, which enhanced root growth and thus increased the potential for higher nutrient uptake. Lower nutrient uptake under no-mulching treatment might be due to low moisture content in the soil and sub-optimal thermal regimes (Bhagat and Acharya, 1987) [7]. Mitra and Mandal (2012) [12] also reported that nutrient uptake is highest in mulching plots than the non mulching plots.

Table 3: Effect of tillage, mulching and INM practices on N, P and K uptake of late sown *toria*

Treatments	Plant N, P and K uptake (kg/ha)					
	N-uptake		P-uptake		K-uptake	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Tillage (P)						
P_1: Conventional tillage	22.793	18.173	7.428	6.050	14.223	12.026
P_2: Reduced Tillage	24.451	19.584	8.041	6.524	15.385	12.920
S.Em (±)	0.271	0.151	0.084	0.058	0.086	0.100
CD (P=0.05)	0.938	0.523	0.292	0.202	0.297	0.345
Mulching (M)						
M_1: No Mulching	22.224	17.860	7.231	5.935	13.946	11.804
M_2: Mulching with paddy straw	25.019	19.897	8.238	6.639	15.662	13.142
S. Em (±)	0.271	0.151	0.084	0.058	0.086	0.100
CD (P=0.05)	0.938	0.523	0.292	0.202	0.297	0.345
Nutrient Management(N)						
N_1: 100 % RDF	21.702	17.279	7.052	5.731	13.589	11.416
N_2: 50% RDN +FYM	26.009	20.219	8.429	6.735	15.845	13.278
N_3: 50% RDN +VC	24.307	19.344	7.961	6.452	15.218	12.803
N_4: 50% RDN +EC	22.469	18.672	7.496	6.232	14.566	12.395
S.Em (±)	0.873	0.541	0.204	0.128	0.280	0.186
CD (P=0.05)	2.549	1.580	0.595	0.374	0.816	0.542

Application of 50 per cent N through recommended chemical fertilizer and 50 per cent N through FYM showed the highest NPK content as well as uptake by late sown *toria*, which was significantly superior to other treatments and treatment of 100 per cent recommended dose of fertilizer recorded the lowest N, P and K content and uptake. On an average, there was an increase in uptake of N, P and K to the tune of 18.4, 18.5 and 16.5 per cent, respectively in crops grown with 50 per cent N

through recommended chemical fertilizer and 50 per cent N through FYM as compared to those with 100 per cent of recommended NPK fertilizer alone. This might be attributed to better availability of plant nutrients due to reduced losses of nutrient and slower release of nutrient elements from the FYM. These results are in agreement with the findings of Sharma and Tripathy (1999) [16] in a rice–mustard cropping sequence. Mitra and Mandal (2012) [12] reported that application of FYM along with 50 per cent of recommended chemical fertilizer produces the higher N, P and K uptake compared to 100 per cent of recommended NPK fertilizer alone. Higher nutrient uptake due to application of FYM with chemical fertilizer was also reported by Kumar and Yadav (1995) [10].

Effect on Seed and Stover yield

Between the two tillage treatments, reduced tillage produced significantly higher value for seed yield as well as for Stover yield over conventional tillage (Table 4). Reduced tillage recorded an increase of 9.02 and 7.65 per cent seed yield over conventional tillage during 2016-17 and 2017-18, respectively. The corresponding increase for Stover yield was 6.96 and 6.44 per cent, respectively. This might be due to better availability of soil moisture throughout the crop growing period and thus better distribution and uptake of nutrients under reduced tillage as compared to that of conventional tillage. Sharma (1985) [15] reported that the poor yield performances from the conventional tillage as compared to the minimum tillage have been related to water availability. Rathore *et al.* (1998) [14] observed that mustard seed yield is maximum under minimum tillage system than the conventional tillage system and yield reduces significantly with increasing tillage operations from minimum tillage to conventional tillage.

The seed yield and stover yield of rapeseed was found significantly higher under the treatment mulching with paddy straw, as compared to no-mulching (Table 4). Mulching with paddy straw brought an increase in seed yield of 12.22 and 10.26 per cent, respectively and stover yield of 9.96 and 9.80 per cent, respectively during 2016-17 and 2017-18 over the no mulching treatment. This might be attributed to conservation of soil moisture, efficient utilization of stored soil moisture, reduced weed competition and improved soil physicochemical properties under straw mulching treatment. Singh and Rana (2006) [20] observed that application of organic mulch brings significantly higher seed and stover yields than no-mulch in Indian mustard. It was also reported by Awal and Sultana (2011) [6] that mulching cover brings significantly higher yield of mustard as compared to no-mulching.

Among the four different nutrient management treatments, application of 50 per cent of recommended N through chemical fertilizer and 50 per cent N through FYM produced the highest seed and stover yield (Table 4). The lowest seed yield and stover yield were recorded from the treatment receiving 100 per cent of the recommended N through chemical fertilizer. The treatment comprising of 50 per cent of recommended N through chemical fertilizer and 50 per cent N through FYM brought an increase in seed yield of 19.44 and 16.28 per cent during 2016-17 and 2017-18, respectively. Similarly it brought the increase in stover yield of 12.75 and 13.66 per cent during 2016-17 and 2017-18, respectively. This might be due to higher availability of nutrients under the INM treatment consisting FYM application as FYM directly adds an appreciable amount of macro as well as major micronutrients to the soil. Singh and Singh (2015) [18] reported that seed yield in Indian mustard increases significantly under late sown condition when chemical fertilizers are applied in integration with organic sources of nutrients as compared to the chemical fertilizer alone. Mitra and Mandal (2012) [12] also found that application of organic manures in integration with 50 per cent of recommended doses of NPK results in highest yield in rapeseed.

Table 4: Effect of tillage, mulching and INM practices on seed oil content (%), Seed yield (kg/ha), Stover yield (kg/ha), and oil yield (kg/ha) of late sown *toria*

Treatments	Seed oil content (%)		Seed yield (kg/ha)		Stover yield (kg/ha)		Oil yield (kg/ha)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Tillage (P)								
P_1: Conventional tillage	34.03	33.87	679.17	587.19	1967.95	1754.06	231.22	198.96
P_2: Reduced Tillage	34.11	33.97	740.45	632.12	2104.97	1866.94	252.69	214.77
S.Em (±)	0.03	0.03	9.783	5.43	11.365	12.53	3.13	1.69
CD (P=0.05)	NS	NS	33.85	18.79	39.33	43.36	10.82	5.87
Mulching (M)								
M_1: No Mulching	33.92	33.84	668.92	579.90	1939.86	1725.97	226.96	196.31
M_2: Mulching with paddy straw	34.22	33.99	750.69	639.41	2133.04	1895.03	256.95	217.42
S. Em (±)	0.03	0.03	9.783	5.43	11.365	12.53	3.13	1.69
CD (P=0.05)	0.11	0.11	33.85	18.79	39.33	43.36	10.82	5.87
Nutrient Management(N)								
N_1: 100 % RDF	33.89	33.74	646.53	561.04	1892.01	1675.33	219.25	189.39
N_2: 50% RDN +FYM	34.19	34.04	772.22	652.36	2133.33	1904.17	264.06	222.07
N_3: 50% RDN +VC	34.12	33.97	726.04	623.19	2084.65	1855.83	247.85	211.76
N_4: 50% RDN +EC	34.07	33.92	694.44	602.01	2035.83	1806.67	236.66	204.25
S.Em (±)	0.04	0.04	25.94	22.13	27.58	20.85	8.94	7.58
CD (P=0.05)	0.11	0.11	75.71	64.60	80.50	60.85	26.09	22.13

Effect on Seed oil content and oil yield

The seed oil content of late sown *toria* was not influenced significantly by the two different tillage treatments during both the years of study (Table 4). However, comparatively higher seed oil content was produced by the treatment of reduced tillage (P_2) during the two years of investigation as compared to the treatment of conventional tillage (P_1). But reduced tillage produced significantly higher seed oil yield as compared to conventional tillage. There was an increase of 9.28 and 7.95 per cent seed oil yield over conventional tillage during 2016-17 and 2017-18, respectively. This might be due to higher available soil moisture in reduced tillage plots as soil available moisture is directly related to seed oil content. Hill (1990) [9] also reported that greater seed oil accumulation

is always attributed to the increased moisture availability in minimum tillage particularly during flowering period.

Significantly higher values of seed oil content were recorded by the plants receiving the treatment of mulching with paddy straw (M_2) as compared to non mulching (M_1) during both the years of study (Table 4). The increase in seed oil content under paddy straw mulching (M_2) over un-mulched crop was 0.88 and 0.44 per cent during 2016-17 and 2017-18, respectively. The corresponding increases in seed oil yield due to application of paddy straw mulch were 13.21 and 10.75 per cent, respectively. This might be due to higher available soil moisture under the mulching treatment as compared to the non mulching treatment as available soil moisture is positively related to seed oil accumulation. Abdullah (2014) [1] found higher canola seed oil content in the residue incorporated plots as compared to the plots without residue incorporation.

Among the four nutrient management treatments, application of 50 per cent of recommended N through chemical fertilizer and 50 per cent N through FYM recorded the maximum values for seed oil content and oil yield during both the years of study (Table 4). The lowest oil content and yield values were recorded when the crop was supplied with 100 per cent of the recommended N through chemical fertilizer only. According to Singh (1984) [17], increase in oil content with application of FYM may be attributed to the synthesis of more glycosides, which increases the oil content. Singh and Sinsinwar (2006) [19] also reported that seed oil content and oil yield increases significantly with the incorporation of FYM with chemical fertilizers in Indian mustard.

Conclusion

From the field investigation, it was observed that N, P and K content in seed and stover, uptake by the crop and oil content of late sown *toria*, grown after harvest of *kharif* rice in Assam could be increased by combined approach of reduced tillage associated with paddy straw mulching and integrated nutrient management comprising of 50 per cent recommended dose of nitrogen through chemical fertilizer and 50 per cent nitrogen through FYM. Thus it can be said that the performance of late sown *toria* variety JT-90-1 (*Jeuti*) in Assam could be improved by following the combination of these practices.

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