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Conservation of Soil Moisture and Sustenance of Yield in Late Sown Toria in Sali Rice Fallows through Moisture Conservation and INM Practices

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A B S T R A C T

A field experiment was conducted during *rabi* seasons of 2016-17 and 2017-18 at the Instructional-cum-Research (ICR) Farm, Assam agricultural university, Jorhat, India to evaluate the effect of tillage, mulching and integrated nutrient management practices on soil moisture conservation and yield of late sown *toria* after harvest of winter rice. 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 data of two years experiment revealed that between the tillage treatments, reduced tillage practice recorded the higher values of soil moisture contents at sowing, flowering, siliqua development and harvesting stages along with the growth and yield attributing characters as well as the seed and stover yield. The reduced tillage (P_2) recorded significantly higher seed yield (9.02 % and 7.65 % higher) and stover yield (6.96 % and 6.44 % higher) than conventional tillage (P_1). Similarly, mulching with paddy straw (M_2) also produced significantly higher soil moisture contents during the different growth stages, growth and yield attributing characters, seed yield (12.22 % and 10.26 % higher) and stover yield (9.96 % and 9.79 % higher) of the crop. Among the nutrient management practices, 50% of RDN through chemical fertilizer + 50% N through FYM (N_2) brought the significantly highest values of soil moisture content at harvest in 0-15 cm soil depth during the year 2016-17 along with growth and yield attributing characters, seed yield and stover yield. The crop brought highest net return (Rs.25282/ha) and benefit-cost ratio (2.40) when it was grown under reduced tillage (P_2) combined with paddy straw mulching (M_2) and fertilized with 50 % of recommended N through chemical fertilizer and 50 % N through FYM (N_2).

Introduction

Rapeseed-mustard is the second most important edible oilseed crop in India after groundnut, which shares 27.8% in the India's oilseed economy. India occupies first place in 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). In Assam, rapeseed occupies an area of only 2.86 lakh ha accounting 1.99 lakh tones of production and productivity being 698 kg/ha (Anonymous, 2016b). 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 eastern part of Uttar Pradesh. In Assam, it is the main source of vegetable oil and about 90 per cent of the crop is cultivated by the farmers in marginal and sub-marginal land. In Assam, Rapeseed is grown entirely as a rainfed crop due to non–availability of irrigation facilities.

Adoption of conservation agriculture techniques like minimum mechanical soil disturbance through reduction of tillage operations along with management of crop residue through mulching could be a sustainable solution to the problems faced in the rainfed areas. It has been found that residue mulching decreases soil moisture loss by reducing soil temperature and evaporation. It thus promotes favorable soil biotic activities, reduces hard soil setting and contributes plant nutrients (Pal *et al.*, 1994).

Intensive crop cultivation practices coupled with unbalanced fertilizer application and restricted use of organic manures is also considered as one of the important constrains of rapeseed production. As these practices have made the soils not only deficient in the important nutrients, but also deteriorated the overall soil health. In order to maintain good soil health and to bring the soil as a reservoir of all the essential plant nutrients, it is necessary to use organic manures in conjunction with chemical fertilizers. Thus integrated nutrient management (INM) could be a better option in modern intensive cropping systems. The organic components of the integrated nutrient management practices also helps in conservation of soil moisture by moderating soil temperature and increasing water holding capacity of soil. Under such circumstances, adoption of minimum or reduced 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). Keeping all these facts in view, the field investigation was performed to find out the effect of mulching, reduced tillage and integrated nutrient management on soil moisture conservation and yield of late sown *toria* in Sali rice fallows under rainfed condition.

Materials and Methods

A field study was carried out during *rabi* seasons of 2016-17 and 2017-18 at Instructional Cum Research (ICR) farm, Assam Agricultural University, Jorhat ($26^0 47^/$ N latitude, $94^0 12^/$ E longitude and at an altitude of 86.6 m above mean sea level). The soil of the experimental site was sandy loam having medium available N (301.06 kg/ha and 282.24 kg/ha) and K_2O (161.28 kg/ha and 154.56 kg/ha) and low available P_2O_5 (21.03 kg/ha and 19.24 kg/ha) with acidic soil reaction (pH 5.5 and 5.4). The experiment was laid out in split plot design with three replications and sixteen treatments. The treatments in the main plots comprised of four moisture conservation practices *viz.,* 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 treatments in sub-plots comprised with four nutrient management practices *viz.,* N_1:100 % Recommended dose of fertilizer (RDF) NPK (40,35 and 15 kg/ha of N, P_2O_5 and K_2O), 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. The late

sown *toria* var. 'JT-90-1' (*Jeuti*) was sown by following 13 kg/ha (15.6 g/plot) seed rate in the second week of December during both the years with a row to row spacing of 25 cm and plant to plant spacing of 5-7 cm. Manure and fertilizers were applied into the plots according to the treatments discussed above. Among the treatments, half of the recommended dose of nitrogen and full doses of phosphorus (P_2O_5), potassium (K_2O) and organic manures were applied uniformly one day before sowing in the furrows and were incorporated into the soil. The remaining half of the nitrogen was top dressed after weeding operation at 22 days after sowing. The N, P_2O_5 and K_2O were applied in the form of Urea, SSP and MOP, respectively. Adequate plant protection measure was taken by spraying Chlorpyriphos 20 EC at the rate of 2 ml/l twice at ten days interval to control the mustard aphid infestation. Soil moisture content was recorded from 0-15 cm depth by soil auger at sowing, flowering, siliquae development stages and before harvest of crop. The statistical analyses of the observations were done using standard statistical procedures given by Panse and Sukhatme (1985). The crop was harvested by cutting at the base in the second week of March. The cost of cultivation, gross and net returns was calculated by taking into account the prevailing market price of inputs and output.

Results and Discussion

Soil moisture content

The soil moisture content at 0-15 cm depth was influenced significantly by two different tillage treatments at sowing, flowering, siliqua development and harvest of late sown *toria* during both the years of study (Table 1). Significantly higher soil moisture content was produced by the treatment of reduced tillage, as compared to the treatment of conventional tillage. This might be due to reduction of evaporation loss of water by the larger soil aggregates. Similar result was obtained by Rathore *et al.*, (1998). Van Eerd *et al.*, (2004) reported that reduced tillage with stubble retention increases soil water content by reducing surface runoff and evaporation losses and increasing soil water infiltration.

Significantly the higher values of soil moisture content at 0-15 cm depth were recorded in the plots treated with paddy straw mulching than the treatment without mulching (Table 1). This might be due to optimization of soil moisture and thus reduction of evaporation loss from the soil by the mulch cover. Ramakrishna *et al.*, (2006) also reported that with mulch, soil moisture is higher and more uniform. Zhou *et al.*, (2011) found that soil surface mulch like straw mulch effectively reduces the soil surface evaporation, increases the rainwater retention and thus increases the soil water storage.

During the year 2016-17, there was no statistical difference in soil moisture contents between the three integrated nutrient management practices. However, nutrient management through 100% chemical fertilizer recorded significantly lowest soil moisture content at 0-15 cm depth in all the stages. This might be due to the fact that the organic manures act as a barrier to evaporation loss of soil moisture by soil temperature optimization. During the year 2017-18, the effect of four different nutrient management practices on the soil moisture content was found to be statistically non significant at all the growth stages of the crop. Jaybhay *et al.*, (2015) found that integrated nutrient management practices comprising 50 per cent recommended dose of fertilizer through chemical fertilizer and 50 per cent through FYM records significantly highest soil moisture content.

Yield characters

Yield attributing characters like plant population, number of primary branches per plant and number of siliquae per plant were increased significantly in the plots prepared with reduced tillage (Table 2). This might be due to comparatively higher soil moisture content, better utilization of residual soil moisture and accumulation of comparatively higher organic matter in soil under reduced tillage system as compared to the conventional tillage systems. Bonari *et al.*, (1995) and Shekhawat *et al.,* (2016) also found higher yield characters in Indian mustard under reduced tillage plots as compared to the conventional tillage plots.

Plant population per square meter, number of primary branches per plant, number of siliquae per plant and number of seeds per siliqua were influenced significantly by two different mulching treatments and mulching with paddy straw recorded the higher values of these parameters (Table 2). This might be due to higher soil moisture conservation by reducing evaporation loss from soil, optimization of soil temperature, reduced weed population and gradual increase in soil organic matter through decomposition of mulch material in the plots receiving the treatment of mulching with paddy straw. Awasthi *et al.,* (2007) also reported higher values of these yield characters with the application of paddy straw mulch in Indian mustard over the no-mulch.

Among the four different nutrient management practices, integrated nutrient management comprising of 50 per cent of recommended N through chemical fertilizer and 50 per cent N through FYM showed highest values for these yield attributing characters. The lowest values for the growth and yield attributing characters were recorded by the plants receiving 100 per cent of the recommended N through chemical fertilizer. This might be due to supply of all required plant nutrients by the organic as well as inorganic sources in optimum quantity and optimization of soil physical, chemical and biological properties under the integrated nutrient management system. Saikia (2011) also found that integration of 50 per cent N through organic manure along with 50 per cent N through chemical fertilizer significantly increases the plant population, number of primary branches per plant, number of siliquae per plant and number of seeds per siliqua in Indian mustard. Shukla *et al.,* (2002) reported that application of inorganic fertilizers integrated with FYM significantly improves the yield attributes like number of siliquae/plant and number of seeds/siliqua over the treatments receiving inorganic fertilizers alone.

Yield

Both moisture conservation practices i.e. reduced tillage and mulching brought higher values for seed and stover yield of late sown *toria* during both the years of investigation (Table 3). Under reduced tillage treatments, an increase of 9.02 and 7.65 per cent in seed yield over conventional tillage during 2016-17 and 2017-18, respectively was observed as compared to the conventional tillage practice. The corresponding increase vales for stover yield were 6.96 and 6.44 per cent, respectively. This might be due to better availability of soil moisture throughout the crop growing period under reduced tillage as compared to that of conventional tillage. Abdullah (2014) found 24 per cent higher seed yield in canola under the treatment of minimum tillage with residues as compared to the conventional tillage without residue.

Similarly, mulching with paddy straw brought 12.22 and 10.26 per cent increase in seed yield during 2016-17 and 2017-18,

respectively. The corresponding increases in stover yield due to application of paddy straw mulch were 9.96 and 9.80 per cent, respectively.

This might be due to efficient utilization of stored soil moisture, reduced weed competition and improved soil physico-chemical properties under straw mulching treatment. Awal and Sultana (2011) also observed that different mulch covers bring a significantly higher yield of mustard as compared to no-mulching. Singh and Rana, (2006) reported that application of organic mulch brings significantly higher seed and stover yields of Indian mustard which are significantly more than no-mulch.

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. The increase in seed yield under integrated nutrient management practice comprising of 50 per cent of recommended N through chemical fertilizer and 50 per cent N through FYM over chemical fertilization alone (100 per cent of the recommended N through chemical fertilizer) were 19.44 and 16.28 per cent during 2016-17 and 2017-18, respectively. The corresponding increases in stover yield due to INM practice with FYM were 12.75 and 13.66 per cent, respectively. This might be due to higher availability of nutrients under the INM treatment consisting FYM application.

Table.1 Effect of tillage, mulching and INM practices on soil moisture content in 0-15 cm depth at different growth stages of late sown *toria*

Treatments	Soil moisture content (%)							
	Sowing		Flowering		Siliqua development		Harvest	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Tillage (P)								
P_1: Conventional tillage	17.24	17.94	18.54	15.65	15.58	13.52	18.03	17.47
P_2: Reduced Tillage	17.62	18.33	19.04	17.28	16.45	14.19	18.94	17.86
S.Em (±)	0.064	0.069	0.132	0.098	0.199	0.138	0.059	0.069
CD (P=0.05)	0.22	0.24	0.46	0.34	0.69	0.48	0.20	0.24
Mulching (M)								
M_1: No Mulching	17.22	17.92	18.43	15.74	15.56	13.39	17.74	17.45
M_2: Mulching with paddy straw	17.64	18.36	19.15	17.19	16.48	14.31	19.23	17.89
S. Em (±)	0.064	0.069	0.132	0.098	0.199	0.138	0.059	0.069
CD (P=0.05)	0.22	0.24	0.46	0.34	0.69	0.48	0.20	0.24
Nutrient Management(N)								
N_1: 100 % RDF	17.24	17.92	18.68	16.82	15.94	13.52	18.02	17.45
N_2: 50% RDN +FYM	17.48	18.24	18.71	16.60	16.03	13.93	18.74	17.77
N_3: 50% RDN +VC	17.51	18.21	18.82	16.27	16.06	13.97	18.64	17.74
N_4: 50% RDN +EC	17.50	18.18	18.96	16.16	16.03	13.99	18.56	17.71
S.Em (±)	0.082	0.087	0.12	0.176	0.112	0.206	0.141	0.087
CD (P=0.05)	NS	NS	NS	NS	NS	NS	0.41	NS

Table.2 Effect of tillage, mulching and INM practices on plant population per square meter, number of branches per plant and number of siliqua per plant of late sown *toria*

Treatments	Plant population/m^2		No. of primary branches/plant		No. of siliquae/ plant	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Tillage (P)						
P_1: Conventional tillage	91.92	70.44	5.37	4.29	51.99	44.65
P_2: Reduced Tillage	93.65	72.00	5.96	4.88	54.56	47.66
S.Em (±)	0.494	0.488	0.056	0.192	0.846	0.597
CD (P=0.05)	1.71	NS	0.19	NS	NS	2.07
Mulching (M)						
M_1: No Mulching	91.54	69.90	5.16	4.18	50.70	43.75
M_2: Mulching with paddy straw	94.02	72.54	6.16	4.99	55.85	48.57
S. Em (±)	0.494	0.488	0.056	0.192	0.846	0.597
CD (P=0.05)	1.71	1.69	0.19	0.66	2.93	2.07
Nutrient Management(N)						
N_1: 100 % RDF	92.26	70.72	5.29	4.33	50.32	42.81
N_2: 50% RDN +FYM	93.26	71.70	5.93	4.96	57.90	48.76
N_3: 50% RDN +VC	92.85	71.29	5.76	4.63	52.88	46.68
N_4: 50% RDN +EC	92.76	71.17	5.67	4.42	52.00	46.38
S.Em (±)	0.558	0.478	0.154	0.157	0.718	0.675
CD (P=0.05)	NS	NS	0.45	0.46	2.09	1.97

Table.3 Effect of tillage, mulching and INM practices on No. of seeds/siliqua, Seed yield (kg/ha) and Stover yield (kg/ha) of late sown *toria*

Treatments	No. of seeds/siliqua		Seed yield (kg/ha)		Stover yield (kg/ha)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Tillage (P)						
P_1: Conventional tillage	21.42	19.78	679.17	587.19	1967.95	1754.06
P_2: Reduced Tillage	21.71	19.97	740.45	632.12	2104.97	1866.94
S.Em (±)	0.33	0.31	9.783	5.43	11.365	12.53
CD (P=0.05)	NS	NS	33.85	18.79	39.33	43.36
Mulching (M)						
M_1: No Mulching	20.83	19.22	668.92	579.90	1939.86	1725.97
M_2: Mulching with paddy straw	22.30	20.54	750.69	639.41	2133.04	1895.03
S. Em (±)	0.33	0.31	9.783	5.43	11.365	12.53
CD (P=0.05)	1.15	1.06	33.85	18.79	39.33	43.36
Nutrient Management(N)						
N_1: 100 % RDF	20.92	19.25	646.53	561.04	1892.01	1675.33
N_2: 50% RDN +FYM	22.70	21.12	772.22	652.36	2133.33	1904.17
N_3: 50% RDN +VC	21.29	19.70	726.04	623.19	2084.65	1855.83
N_4: 50% RDN +EC	21.36	19.45	694.44	602.01	2035.83	1806.67
S.Em (±)	0.43	0.46	25.94	22.13	27.58	20.85
CD (P=0.05)	NS	1.34	75.71	64.60	80.50	60.85

The FYM directly adds an appreciable amount of macro nutrients as well as major micronutrients to the soil, which could contribute to the enhanced yield. Mitra and Mandal (2012) also reported similar results in rapeseed crop. Singh and Sinsinwar, (2004) found favorable effect of application of FYM along with chemical fertilizer on yield of Indian mustard.

In conclusion, the field investigation revealed that soil moisture can be effectively conserved in soils 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 either through FYM or vermi-compost. Thus the seed and stover yield of *Toria* variety JT-90-1 (*Jeuti*) grown after harvest of *kharif* rice could be increased by this integrated approach in Assam under late sown condition.

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