

PRODUCTIVITY OF RAINFED MUSTARD IN RELATION TO TILLAGE AND MULCHING

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Abstract

Field experiments were conducted at the Regional Agricultural Research Station of Bangladesh Agricultural Research Institute, Jessore during *rabi* (winter) seasons of 1999-2001 to study the tillage and mulching effects on conservation of residual soil moisture, yield attributes and yield of mustard (cv. Daulat.). Three different tillage methods, namely minimum, reduced and conventional tillage were used in the main plots and three different mulch materials, namely rice straw, water hyacinth, black polythene including no mulch were used in the sub-plots. It was observed that reduced tillage and polythene mulch or rice straw mulch conserve more moisture than other tillage methods and mulch application. Tillage practice significantly influenced the dry matter, yield and yield components of mustard. Reduced tillage gave consistently the highest seed yield (969 kg/ha), while minimum tillage gave the lowest seed yield (92 kg/ha). Mulching also resulted in better crop growth and increased yield. Significantly higher seed yield (1164 kg/ha) was recorded from black polythene mulch followed by rice straw mulch (1089 kg/ha). The yield of mustard was obtained due to the interaction effects on reduced tillage and polythene mulch followed by conventional tillage and polythene mulch, which was found superior to all other treatments. Results revealed that polythene mulch or rice straw mulch accompanied by reduced tillage was economically profitable for mustard cultivation/production under rainfed condition.

Key Words: Rainfed mustard, tillage, mulching.

Introduction

Crop production in Bangladesh is predominantly based on rainfall and its annual distribution. About 90% of the total rainfall is received in monsoon (June to September) and in the remaining months (October to May) drought of different degrees occurs in almost all areas of the country (Mondal and Wahhab, 2001; Khatun, 2004). In Bangladesh, drought is a common occurrence almost in each and every crop and the dry land farming is being affected by drought.

Depending on the severity of drought, the estimated yield reduction in Bangladesh varies from 10 to 70% (BARC, 1990). About 43% of total

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agricultural land in Bangladesh has got irrigation facilities and remaining either under rainfed cultivation during winter season or fallow the next *kharif* season (Anon., 2002).

Mustard is one of the major oilseed crops that occupy 78% of the area and contribute nearly 62% of the total oilseed production in Bangladesh (BBS, 2003). In all the cropping systems, mustard is depended predominantly on the residual soil moisture from the preceding crop. However, per hectare yield of rainfed mustard is low. The poor crop performance of mustard under rainfed condition may be due to lack of inadequate soil and water management practices with reference to soil water shortage in the soil profile. Adequate plant population consistent with available water status and other inputs of crop production is a precondition for maximizing yield. In the case of dry land farming, the use of mulch is beneficial which conserves soil moisture, reduces soil temperature, minimizes evaporation loss and enhances root growth (Allamaras *et al.*, 1977; Gupta, J.P. and Gupta, 1986). The effect of mulch on soil temperature, moisture regime and root growth as well as yield depend on the climatic environment, made of mulch application and quality and quantity of mulch materials. On the contrary, tillage plays a vital role in conservation of soil moisture at different depths in rainfed cultivation. It also improves soil condition by altering the mechanical impedance to root penetration, hydraulic conductivity and holding capacity, which in turn affects plant growth (Dexter, 1989). Since, most of the lands in northern-part of Bangladesh remains fallow in winter season due to shortest of water. In this situation, the use of mulch and tillage method is important for plant growth. Considering scarcity of water, the present experiment was undertaken to find out the suitable tillage methods and mulch application to conserve soil moisture for the better growth and yield of mustard during dry season.

Materials and Method

The experiment was conducted at the Regional Agricultural Research Station of the Bangladesh Agricultural Research Institute, Jessore during *rabi* (winter) seasons of 1999-2000 and 2000-2001 under rainfed condition. The soil was silt loam (Old Ganges Alluvial Sediment) in texture belonging to Gopalpur series (AEZ-11) harvesting pH (5.8 to 7.8), organic matter (1.25 to 2.15%), total nitrogen (0.080%), available phosphorus (13 ppm), exchangeable potassium (2 meq/100 g) and available sulphur (12 ppm). The crop received 128 mm in 1999-2000 and 189 mm in 2000- 2001 during crop growth period. Mean maximum and minimum air temperatures were 28.98 and 16.07°C in 1999-2000 and 30.10 and 15.19 in 2000-2001, respectively, during crop season.

The experiment consisted of 3 different tillage methods viz., minimum tillage (one ploughing followed by laddering), reduced tillage (two ploughings followed

by laddering) and conventional tillage (4 ploughings followed by laddering) and 3 different mulch materials viz., rice straw (cover on the soil surface @ 2.5 t/ha, water hyacinth (cover on the soil surface @ 2.0 t/ha) and black polythene (cover on the soil surface 0.05 mm thickness) including no mulch. The trial was laid out in split plot design with four replications. The dimensions of individual plots were 4m × 3m. Tillage treatments were placed in the main plots and mulch treatments in the sub-plots. A fertilizer dose of 25-40-25-2-1 kg NPKSZnB/ha was applied in the field as urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid, respectively. All fertilizers were applied at the time of final land preparation and incorporated with the soil. Mustard seeds (cv. Daulat) were sown in lines (30cm x 10cm) on 15 November in 1999 and 13 November in 2000. Soil samples were collected at a depth of 0-15cm and 16-30 cm from soil to maturing determined by over dressing the samples at 105°C for 24 hours. Profile soil temperature of the experimental plots also was monitored at 10-day intervals in 0-15 cm soil depth at 12 to 1 noon. Plant protection measure was taken whenever needed. Seed yield and yield contributing characters of 10 days interval of mustard were collected at harvest. Data on different parameters were subjected to analysis of variance and the means were compared by DMRT at 5% level of probability.

Results and Discussion

Soil moisture and soil temperature regime

Soil moisture percentage of mustard trial varied among the tillage methods and mulch materials. Soil moisture in the tilled soil under cropping decreased at higher rates initially followed by slower rates (Fig. 1). In tilled and unfilled soils, the maximum moisture was lost from the surface layer (0- 15 cm). The amount of moisture loss from a well tilled or minimum tilled plots was almost similar irrespective of depth. Soil moisture of well tilled and minimum tilled plots decreased slowly and steadily in both the years. Soil moisture loss pattern varied appreciably due to variation of soil depths among the mulch materials (Fig. 2). During initial stage, evaporation was mostly governed by the external evaporation or by the soil hydraulic properties. In no mulch, soil moisture loss was rapid initially at both soil depths and then it changed steadily but slowly. Apparently the drying of surface soil without mulch cover was quicker in comparison with minimum tilled soil. The quick drying is perhaps due to increased radiant energy available for evaporation on rough soil surface. The soil moisture content remained fairly high in black polythene mulch followed by rice straw and water hyacinth mulch (Fig. 2). The soil moisture content was slightly higher at soil depth of 16-30 cm than at 0-15 cm depth under both mulch and no mulch conditions. Mulch helped keep the surface evaporation minimal. Considerable variation in soil temperature was also observed between tillage

methods and mulch conditions (Fig. 3). Soil temperature was slightly higher in minimum tillage than in the reduced and conventional tillage. Soil temperature was higher under no mulch condition. Temperature was lower under black polythene and rice straw mulch followed by water hyacinth mulch. The reduction in soil temperature under polythene and rice straw mulch might be due to the higher albedo of the black polythene and rice straw mulch which might have incidental solar radiation and decreased the amount of downward transmission of heat. The increase of soil temperature of the surface soil without mulch was quicker compared to tilled soil.

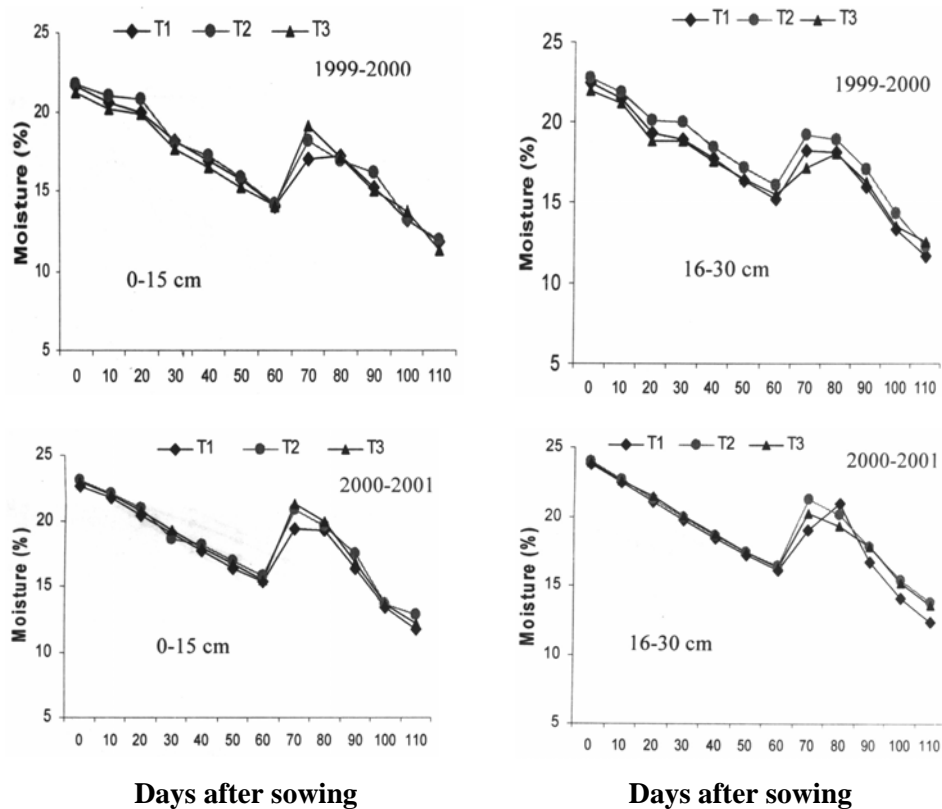


Fig. 1. Effect of tillage on soil moisture content over the growing period of mustard during 1992-2001 at 0-15 cm and 16-30 cm depths (T₁= Minimum tillage, T₂= Reduced tillage and T₃= Conventional tillage)

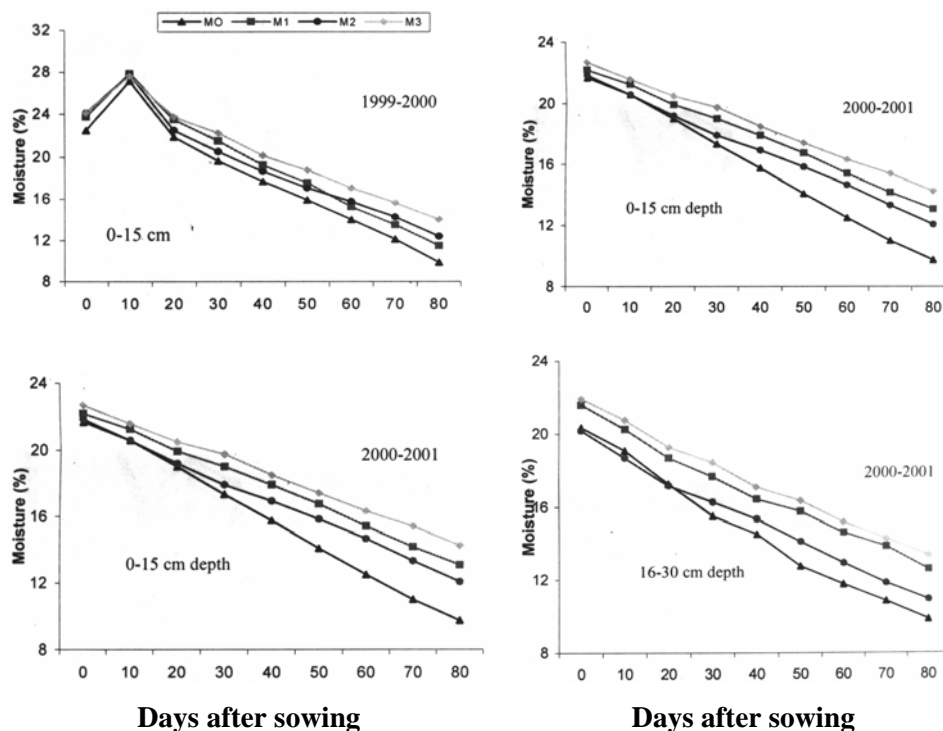


Fig. 2. Effect of mulch on soil moisture content over the growing period of mustard during 1999-2001 at 0-15cm and 16-30cm depths, (M₀= No mulch, M₁= Rice straw, M₂= water hyacinth, M₃= Black polythene mulch)

Dry matter production

Tillage methods were found to have significant influence on dry matter (DM) plant of mustard at 45 and 65 DAS and at maturity in 2000-2001 only (Table 1). The highest DM reduced tillage followed by that in conventional tillage. Significantly the lowest DM was obtained from minimum tillage methods except 25 DAS. Different mulching significantly influenced the DM plant of mustard throughout the growing period except at 25 DAS in 2000-2001 (Table I). However, DM of mustard increased with the advancement of time irrespective of mulch practices. Initial rate of increase was very low, but after 25 DAS there was a rapid increase of dry matter and continued upto maturity. Black polythene mulch showed highest DM followed by rice straw mulch irrespective of growth stages. Black polythene mulch produced the highest DM than the others mulches possibly due to day time soil temperature reduction and improved the conservation of soil moisture. The lowest DM/plant was recorded from no-mulch treatment.

Table 1. Pooled value of dry matter production of mustard over time as affected by tillage and mulching.

Treatments	25 DAS	45 DAS	65 DAS	Maturity
Tillage				
Minimum tillage	0.21b	2.13c	5.90b	6.68c
Reduced tillage	0.22a	2.22b	6.63a	8.72a
Conventional tillage	0.21b	2.31a	6.71a	8.31ab
Mulching				
Nomuich	0.21b	1.93c	5.25c	6.62c
Rice straw mulch	0.22b	2.27b	6.73b	8.3 lb
Water hyacinth mulch	0.21b	2.14b	5.96c	7.43c
Black polythene mulch	0.29a	2.56a	7.7 Ia	9.48a

Figures in a column having same or without letter(s) do not differ significantly at 5% level of probability, DAS = Days after sowing.

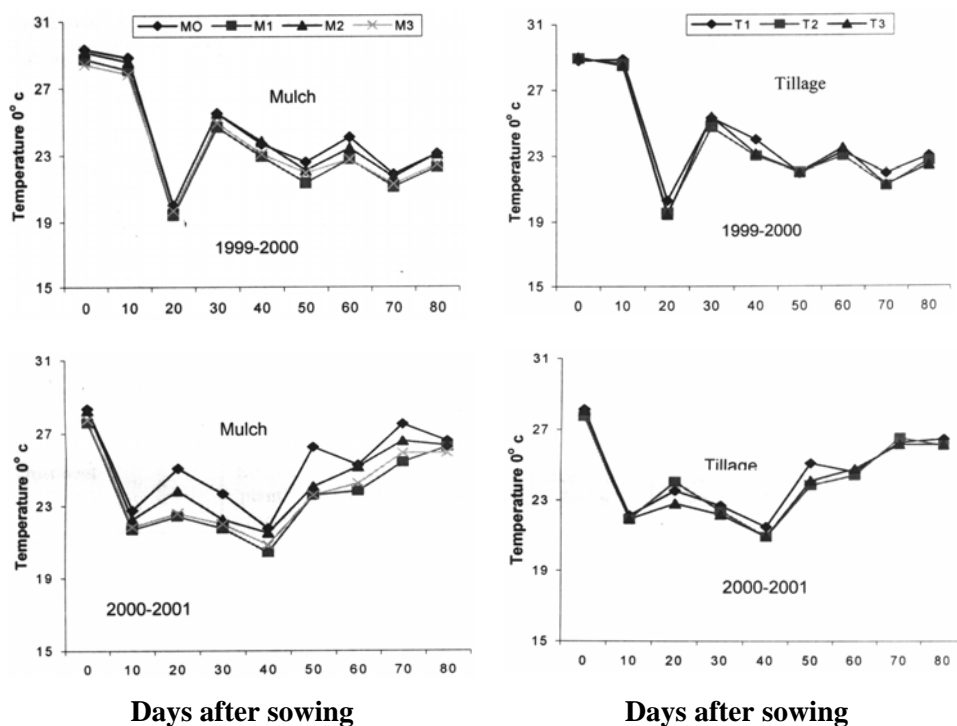


Fig. 3. Effect of mulch on soil temperature over the growing period of mustard during 1999-2001 (M_0 = No mulch, M_1 = Rice straw mulch, M_2 = water hyacinth, M_3 = Black polythene mulch and T_1 = minimum tillage, T_2 = Reduced tillage and T_3 = Conventional tillage)

Effect of tillage method

Tillage methods significantly influenced number of siliquae/plant, seeds/siliqua and seed yield and dry weed biomass. Tillage methods followed to show significant influence of 1000-seed weight and straw yield (Table 2). Number of siliquae/plant and seeds/plant produced with conventional tillage and reduced tillage were statistically identical but both the tillage methods produced significantly higher siliquae and seeds/plant than minimum tillage. Among the different tillage practices, the highest seed yield (969 kg/ha) was obtained with reduced tillage. Reduced tillage have led to more moisture conservation and increased water uptake and nutrient by the plant and consequently resulted high siliquae/plant and seeds siliqua and higher grain yield. Significantly the lowest yield were obtained from minimum (921 kg/ha and conventional tillage (948 kg/ha), but these two tillage methods were statistically identical. This result might be due to less root growth as well as less nutrient uptake which caused lower siliquae/plant and less number of seeds/siliqua and ultimately resulted in lowest seed yield. Weed biomass was also significantly influenced by tillage methods (Table 2). Minimum tillage produced the highest dry weed biomass and it was significantly different from reduced and conventional tillage. However, weed biomass obtained from reduced tillage was at par with conventional tillage. This result might have been due to higher weed population in minimum tillage methods than other tillage methods. Similar results were reported by Quddus (1989) in wheat crop.

Table 2. Pooled value of yield attributes, seed yield and weed biomass of mustard as affected by tillage and mulching.

Treatments	Siliquae/ plant	Seeds siliqua/	1000-seed wt (g)	Seed yield (kg/ ha)	Straw (kg/ ha)	Dry weed biornass (kg/ ha)
Tillage						
Minimum tillage	75.41c	11.31b	2.34	921b	2306	658a
Reduced tillage	91.84ab	13.09a	2.56	969a	2355	494b
Conventional tillage	105.84a	13.12a	2.41	948b	2383	482b
Mulching						
Nomuich	69.66c	11.62b	2.25b	835c	1941c	675a
Rice straw mulch	93.83ab	12.62a	2.54a	1089ab	2518a	512b
Water hyacinth mulch	87.83c	12.02a	2.37ab	998b	2237b	593ab
Black polythene mulch	104.79a	13.00a	2.58a	1164a	2697a	397d

Figures in a column having same or without letter(s) do not differ significantly at 5% level of probability.

Effect of mulching

Number of siliquae/plant, seeds/siliqua, 1000-seed weight, seed yield, straw yield and dry weed biomass of mustard were significantly influenced by different mulch treatments (Table 2). Application of polythene mulch produced significantly highest straw yield, siliquae/plant, seeds/siliqua, 1000-seed, seed yield and straw yield of mustard followed by rice straw mulch. The lowest yield of mustard was recorded in no-mulch treatment. The reason for high yield in polythene and straw mulch treatments might be due to lower soil temperature and conserves more moisture. Yield of mustard increased in black polythene and rice straw mulch over no mulch to the extent 39% and 30%, respectively. Similar results were reported by Duncan *et al.* (1992) and Marumota *et al.* (1991). They stated that polythene mulch conserved soil moisture and increased root activity. Sharma *et al.* (1985) and Mondal *et al.* (2003) also reported that straw mulch was more effective in mustard than soil mulch. On the contrary, the highest dry weed biomass was found in no mulch followed by water hyacinth mulch. Polythene mulch produced the lowest weed biomass. This might be due to preventing of the rapid development of weeds during early growth stages. Similar results were reported by Mondal *et al.* (2003) and Midmore *et al.* (1984). They stated that mulch was capable of reducing certain species of both mono and dicotyledonous weeds. Moreover, application of black polythene emulsion (PE) film was very effective for weed control as stated by Lal (1974) maize crop and Ayanaba and Okigbo (1974).

Interaction between tillage methods and mulching

Interaction effect between tillage methods and mulching did not show any significant effect for any of the characters under study except the seed yield (Table 3). The highest seed yield was recorded from the treatment combination of reduced tillage with black polythene mulch (1218 kg/ha) followed by reduced tillage with rice straw (1108 kg/ha) and conventional tillage with black polythene mulch (1194 kg/ha). The reason for higher yield in the black polythene mulch might be due to decreased soil temperature and diurnal temperature oscillation and more efficient conservation of water which favoured growth of the crops. The lowest yield was recorded in no- mulch irrespective of tillage methods.

Table 3. Interaction effect of tillage and mulching on seed yield of mustard (Pooled).

Interaction of tillage and mulching	Seed yield (kg/ha)	Gross return (Tk./ha)
Minimum tillage x No mulch	791e	12260
Minimum tillage x Rice straw mulch	1002d	15531
Minimum tillage x Water hyacinth mulch	1013bc	15701
Minimum tillage x Black polythene mulch	1027bc	15918
Reduced tillage x No mulch	780e	12090
Reduced tillage x Rice straw mulch	11 08ab	17174
Reduced tillage x Water hyacinth mulch	1 023bc	15856
Reduced tillage x Black polythene mulch	1218a	18879
Conventional tillage x No mulch	787e	12198
Conventional tillage x Rice straw mulch	1056bc	16368
Conventional tillage x Water hyacinth mulch	958cd	14849
Conventional tillage x Black polythene mulch	11 94a	18507

Figures in a column having same or without letter(s) are not significantly different at 5% level of probability.

Economic evaluation

In economic point of view, reduced tillage with water hyacinth mulch showed higher gross margin, benefit-cost ratio and marginal rate of return followed by straw mulch. In other words, considering above all the situations, reduced tillage with straw mulch gave better performance due to its easy availability.

Table 4. Cost and return analysis of mustard as affected by tillage and mulching (Pooled).

Treatments	Seed yield (kg/ha)	Straw yield (kg/ha)	Gross return (Tk/ha)	Total variable cost (Tk/ha)	Gross margin (Tk/ha)	Benefit cost ratio	Marginal rate of return
Minimum tillage	921	2306	14429	9225	6204	1.67	-
Reduced tillage	969	2355	16378	10560	5637	1.53	0.58
Conventional tillage	984	2383	15886	11020	4866	1.44	0.25
No mulch	835	1941	13929	7520	6393	1.85	-
Rice straw mulch	1089	2518	18138	10120	8019	1.79	1.63
Water hyacinth mulch	998	2237	16587	8430	8158	1.97	2.94
Black polythene mulch	1164	2697	31527	18315	1076	1.06	0.51

Variable cost = Cost incurred in fertilizer, seed purchase and labour

Price:

Mustard seed = 15.50 Tk./kg, Mustard straw = 0.50 Tk./kg, Black polythene = 52.00 Tk/kg, Urea = 6.00 Tk./kg, TSP = 12.00 Tk./kg, MP = 8.00 Tk./kg, Sulphur 3.00 Tk./kg., = Zinc 60.00 Tk./kg, Boron = 120.00 Tk./kg.

Conclusion

Two years' study revealed that reduced tillage with black polythene mulch or straw mulch during dry season favoured yield attributes which eventually resulted in high yield of mustard.

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