

Effect of *in-situ* moisture-conservation practices on productivity of rainfed Indian mustard (*Brassica juncea*)

P.L. REGAR*, S.S. RAO AND N.L. JOSHI

Regional Research Station, Central Arid Zone Research Institute, Pali-Marwar, Rajasthan 306 401

Received : February 2007

ABSTRACT

A field experiment was conducted at Pali-Marwar, Rajasthan, during winter season (*rabi*) of 1997-98 to 2001-02 to find out the effect of field bunding and deep tillage during preceding rainy (*kharif*) season and straw mulch on Indian mustard [*Brassica juncea* (L.) Czernj. & Cosson] productivity. Field bunding significantly increased mean mustard seed yield by 14.4% and biological yield by 15.3% over no bunding because of increased availability of soil moisture. Water-use efficiency also increased by 9.7 kg/ha-mm. Deep tillage during monsoon significantly increased the seed yield by 45.5 and 11.1% over pre-monsoon deep tillage in 1999-00 and 2001-02. Straw mulching at 5 tonnes/ha significantly increased mean seed yield by 17.7% over no mulch, with water-use efficiency of 8.3 kg/ha-mm.

Key words : Bunding, Fallow-mustard, Rainfed, Seed yield, Straw mulch, Tillage

Limited availability of soil moisture at critical stages of crop growth is major constraint of rainfed agriculture in semi-arid regions. Keeping the land fallow during rainy season is practised in arid fringes due to low and erratic rainfall, causing recurrent crop failure. Moisture conservation practices play significant role in success of dryland agriculture. Field bunding across the slope retains run-off in the cultivated field and facilitates its infiltration. Summer deep ploughing improves soil porosity, water intake rate and reduces the run-off, whereas deep ploughing during monsoon conserves the stored soil moisture, breaks soil capillary, retards evaporation and acts as soil mulch (Mishra *et al.*, 2005). Organic mulches are poor conductor of heat that effectively reduce soil temperature and maintain soil moisture for longer period (Vaidya *et al.*, 1995). Mustard, being a deep-rooted hardy crop to extract more moisture from deeper layer, was selected as test crop in a fallow-mustard cropping sequence. Keeping this in view, a field experiment was conducted to study the effect of bunding and deep tillage as well as organic mulch on water-use efficiency of Indian mustard under dryland conditions.

MATERIALS AND METHODS

A field experiment was conducted from 1997-98 to 2001-2002 at Regional Research Station, Central Arid Zone Research Institute, Pali-Marwar. The soil was fine, loamy in texture, having 30-45 cm depth and dense underlying layer of *murrum* up to 10-15 m depth. It had pH 8.1,

*Corresponding author (Email: regarp18@yahoo.com)

EC 0.16 dS/m, bulk density 1.39 Mg/m³, field capacity 17.1%, permanent wilting point 7.1% and infiltration rate 13 mm/hr. The soil had 0.35% organic C, 213.0 kg/ha available N, 11.0 kg/ha Olson's P and 203.0 kg/ha exchangeable K. The treatment comprised no bunding (control) and field bunding; pre-monsoon deep tillage and deep tillage during monsoon. Straw mulch treatments were super-imposed at 0 (control), 2.5 and 5 t/ha. The experiment was laid out in split-plot design with combination of bunding and deep tillage in main plots and mulching in subplots, with 4 replications. Field bunding of 2.5 m base width and 0.8 m height was made at the time of initiating the experiment. Deep tillage with tractor-drawn disc plough up to 25 cm depth was applied as per treatment during summer and first week of August when soil was in a friable condition.

The amount and distribution of rainfall received during preceding rainy season was 718.4, 184.7, 351.9, 244.7 and 512.3 mm, respectively, from 1997 to 2001 against the average rainfall of 420 mm of the region (Table 1). Indian mustard var. 'Varuna' was sown during the third week of October every year at ambient temperature 25°C. Nitrogen at 30 kg/ha and P at 8.75 kg/ha were drilled before sowing through urea and diammonium phosphate. Ten days after germination, straw mulch was applied in inter-row spacing uniformly with 80% spread. Crop was harvested in the second week of February. Data on yield and yield attributes were recorded year-wise and analysed. Data on soil-moisture status were recorded before sowing and after harvest of the crop up to 90 cm depth.

RESULTS AND DISCUSSION

Growth and yield

Field bunding significantly improved plant performance during all the years. Plant height (except during 1999–2000) and siliquae/plant increased significantly over no bunding, but the increase in branches/plant was not significant. Biological yield increased significantly by 16.3, 24.9 and 9.1% during 1997–98, 1999–2000 and 2001–02 over no bund (Table 2). The increase in seed yield of mustard was 11.1, 25.0 and 11.1% during 1997–98, 1999–2000 and 2001–02, respectively, over no bunding. Such beneficial effect of field bunding might be due to increased availability of soil moisture (10.3, 6.8 and 9.5 mm), as it prevented run-off and therefore more water was observed in the soil profile. Data on soil moisture use indicated 5.0, 4.2 and 9.8 mm higher use of critical soil moisture under field bunding than under no bunding (Table 3). Meena *et al.* (2002) reported significant increase in chickpea grain yield by 22.9 and 10.5% owing to field bunding in 2 seasons over no bunding. Singh *et al.* (2005) also recorded 89% higher seed yield of mustard by

bunding over the control.

The effect of deep tillage on crop performance was varied between the years. This might be due to the variation in amount and distribution of rainfall received in different years (Table 1). Deep tillage during the monsoon significantly increased the seed yield of Indian mustard by 45.5 and 11.1% over pre-monsoon deep tillage in 1999–2000 and 2001–02. The significant effect of deep tillage during the monsoon on seed yield was not observed in 1997–98 due to very high (171%) rainfall. Interaction effect of field bunding and deep tillage was found significant in increasing seed yield during 1997–98. Maximum seed yield of 0.81 t/ha was obtained under field bunding + deep tillage during monsoon. The effect of pre-monsoon deep tillage under field bunding was minimized because of sealing of pore space (Table 4). Deep tillage during monsoon promoted better root-system development as reflected by higher values of growth and yield attributes (though they did not attain the level of significance), which was ultimately responsible for increased seed yield under this treatment (Phogat and Dharam Pal, 2005).

The effect of organic mulching was significant on plant height, siliquae/plant, biological yield and seed yield (Table 2). Straw mulch at 5 t/ha significantly increased biological yield by 15.9, 39.7 and 35.3% during 1997–98, 1999–2000 and 2001–02 over the control. Seed yield increased significantly by 17.1 and 21.1% due to straw mulch at 5 t/ha during 1997–98 and 2001–02. Application of straw mulch did not have any significant effect during the low-rainfall year (1999–2000). Pratap Singh *et al.* (1996) reported significant effect of straw mulch at 6 t/ha on branches and siliquae/plant and an increase of 35.5% in seed yield. Vaidya *et al.* (1995) reported that straw mulch slowed down the energy exchange

Table 1. Rainfall distribution (mm) preceding and during cropping season

Year	1997–98	1998–99*	1999–2000	2000–01*	2001–02
May	15.3	0.0	0.0	0.0	5.5
June	66.8	17.7	32.3	9.6	44.1
July	91.9	22.5	189.5	186.5	338.9
August	468.9	84.9	123.0	48.6	93.0
September	7.2	20.0	4.1	0.0	19.0
October	68.3	39.6	3.0	0.0	11.8
Total	718.4	184.7	351.9	244.7	512.3

*Soil moisture was not sufficient for sowing the crop

Table 2. Effect of bunding, tillage and mulching on yield attributes and seed yield of Indian mustard

Treatment	Plant height (cm)			Branches/plant			Siliquae/plant			Biological yield (t/ha)			Seed yield (t/ha)		
	1997–98	1999–2000	2001–02	1997–98	1999–2000	2001–02	1997–98	1999–2000	2001–02	1997–98	1999–2000	2001–02	1997–98	1999–2000	2001–02
Bunding															
No bunding	144.8	87.9	110.1	4.3	3.1	2.9	164.4	36.7	80.1	2.67	0.19	2.30	0.72	0.24	0.54
Bunding	173.4	83.7	141.1	4.7	2.9	3.0	195.4	41.3	92.4	3.11	0.48	2.51	0.80	0.30	0.60
SEm±	3.1	1.9	2.3	0.1	0.2	0.2	3.8	1.1	1.9	0.12	0.08	0.06	0.02	0.02	0.01
CD (P=0.05)	9.8	NS	7.3	0.3	NS	NS	12.2	3.7	5.9	0.38	0.27	0.18	0.07	0.06	0.04
Deep tillage															
Pre-monsoon	156.9	84.5	120.6	4.6	2.8	3.0	187.3	38.4	82.6	3.02	1.05	2.32	0.79	0.22	0.54
During monsoon	161.3	87.1	130.7	4.5	3.1	2.9	172.5	39.6	89.9	2.77	1.62	2.49	0.73	0.32	0.60
SEm±	3.1	1.9	2.3	0.1	0.2	0.2	3.8	1.1	1.9	0.18	0.08	0.06	0.02	0.02	0.01
CD (P=0.05)	NS	NS	7.3	NS	NS	NS	12.2	NS	5.9	NS	0.27	NS	NS	NS	0.04
Straw mulching															
Control	150.1	84.6	119.1	4.2	2.9	2.9	151.0	36.9	79.7	2.71	1.11	2.04	0.69	0.25	0.52
2.5 t/ha	159.6	86.7	124.8	4.4	3.0	3.0	180.5	38.7	86.2	2.83	1.34	2.41	0.76	0.28	0.56
5.0 t/ha	167.7	86.1	132.9	4.9	3.0	2.9	208.2	41.3	92.9	3.14	1.55	2.76	0.82	0.28	0.63
SEm±	2.4	2.9	2.3	0.1	0.1	0.1	4.3	1.0	1.8	0.05	0.06	0.10	0.02	0.01	0.02
CD (P=0.05)	6.9	NS	6.8	0.2	NS	NS	12.6	3.0	5.3	0.15	0.17	0.30	0.05	NS	0.05

Table 3. Effect of bunding, tillage and mulching on moisture-use pattern and water-use efficiency (kg/ha-mm) by Indian mustard

Treatment	1997-98				1999-2000				2001-02			
	Initial moisture (mm)	Final moisture (mm)	Moisture use* (mm)	WUE	Initial moisture (mm)	Final moisture (mm)	Moisture use (mm)	WUE	Initial moisture (mm)	Final moisture (mm)	Moisture use (mm)	WUE
<i>Bunding</i>												
No bunding	148.8	71.2	90.3	7.9	116.8	54.9	61.9	3.8	103.0	36.1	66.9	7.9
Bunding	159.1	76.5	95.3	8.4	123.6	57.5	66.1	4.6	112.5	35.8	76.7	8.0
<i>Deep tillage</i>												
Pre-monsoon	157.3	74.0	96.0	8.2	113.9	55.0	58.9	3.6	106.6	32.3	74.4	7.2
During monsoon	150.7	73.7	89.7	8.1	126.5	57.4	69.1	4.6	108.7	39.6	69.1	8.7
<i>Straw mulching</i>												
Control	153.4	75.1	91.0	7.7	118.5	52.3	66.2	3.8	108.0	35.4	72.6	7.2
2.5 t/ha	154.3	73.7	93.3	8.1	118.1	55.9	62.2	4.4	107.2	35.0	72.2	7.7
5.0 t/ha	154.2	72.8	94.1	8.7	126.6	60.4	66.1	4.3	107.8	37.4	70.4	9.0

*Includes 12.7 mm rainfall received during pendency of crop growth

Table 4. Effect of bunding and tillage on seed yield of mustard during 1997-98

Treatment	No bunding	Bunding
Pre-monsoon deep tillage	7.91	6.40
Deep tillage during monsoon	7.91	8.12
CD (P=0.05)	0.93	

at soil surface, thermal diffusion and provided treat insulation, making uniform soil temperature that minimized evaporation losses.

Water use and water-use efficiency

Field bunding was effective in preventing run-off, resulting in higher moisture availability in the soil profile as reflected by enhanced water use (Table 3). Field bunding increased critical water use by 5.0, 4.6 and 9.8 mm over no bunding. This led to increased water-use efficiency to 9.7, 4.6 and 8.0 kg seed/ha-mm in 1997-98, 1999-2000 and 2001-02, respectively. Significant and positive correlation between rainfall and water use ($r=0.88^{**}$) and water use and seed yield ($r=0.94^*$) indicates the importance of field bunding in rainfed agriculture. Meena *et al.* (2002) reported significant effect of field bunding on water-use efficiency of rainfed chickpea.

The effect of deep tillage during monsoon did not increase water use by the following *rabi* crop in the good rainfall years of 1997-98 and 2001-02 (Table 1). However, it was effective during low-rainfall year (1999-2000), which resulted in increased water use by 10.2 mm and water use efficiency by 4.6 kg/ha-mm. Highly significant correlation was noticed between rainfall and water use under deep tillage ($r=0.86^{**}$) and water use and seed yield ($r=0.83^{**}$). Mishra *et al.* (2005) reported that deep tillage retains more soil moisture for a longer period due to more availability of pore spaces.

Organic mulch increased water-use efficiency when the

preceding season rainfall was high and its effect was less when preceding-season rainfall was low. Straw mulch at 5 tonnes/ha increased water-use efficiency by 8.7 and 9.0 kg/ha-mm compared to 7.7 and 7.2 kg/ha-mm under the control during 1997-98 and 2001-02. Pratap Singh *et al.* (1996) reported 62.4% increase in water-use efficiency due to mulching @ 6 t/ha over the control.

It may be concluded that in semi-arid regions where perpetual droughts (2-3 years in a 5-year period) and recurrent crop failure are common phenomenon, field bunding along with deep ploughing during monsoon ensures mustard production.

REFERENCES

- Meena, L.R., Singh, R.K. and Gautam, R.C. 2002. Effect of moisture conservation practices, phosphorus levels and bacterial inoculation on chickpea (*Cicer arietinum*) under rainfed condition. *Indian Journal of Agronomy* 47(3): 398-404.
- Mishra, J.S., Singh, V.P. and Yaduraju, N.T. 2005. Effect of tillage practices and herbicides on weed dynamics and yield of wheat (*Triticum aestivum*) under transplanted rice (*Oriza sativa*)-wheat system in Vertisols. *Indian Journal of Agronomy* 50(2): 106-109.
- Phogat, V.K. and Dharam Pal. 2005. Effect of deep tillage and gypsum on yield, and N, P, K and S uptake by mustard. *Journal of the Indian Society of Soil Science* 53(1): 134-136.
- Singh, Pratap, Mittal, S.P. and Agnihotri, Y. 1996. Moisture use efficiency and yield of mustard as affected by pre-sowing irrigation and mulch. *Indian Journal of Soil Conservation* 24(2): 128-131.
- Singh, R.K., Prasad, S.N., Ali, Shakil, Kumar, Ashok, Singh, K.D., Prasad, Arjun, Singh, S.V. and Parandiyal, A.K. 2005. On-farm evaluation of conservation measures to performance of rainfed crops in semi-arid region. *Indian Journal of Soil Conservation* 33(2): 141-143.
- Vaidya, V.B., Varshneya, M.C., Bote, N.L. and Naidu, T.R.V. 1995. Estimation of thermal efficiency and apparent reflectivity of mulches using soil temperature. *Journal of Maharashtra Agricultural Universities* 20(3): 341-344.