Indian Journal of Agronomy **67** (2): 180–185 (June 2022)

Research Paper

Effective management practices for enhancing castor (*Ricinus communis*) productivity in dryland agriculture

B.S. PARMAR[1], N.I. PATEL[2], BRIJAL R. PATEL[3], JAYDIP MAKWANA[4] AND FORAM K. PATEL[5]

Centre for Natural Resources Management, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat 385 506

Received: March 2022; Revised accepted: June 2022

ABSTRACT

A field experiment was conducted during rainy (*kharif*) season of 2016, 2017 and 2018 at Centre for Natural Resources Management, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, to study the effect of land configurations and mulching on productivity and rainwater-use efficiency of castor (*Ricinus communis* L.). The experiment was laid out in a randomized block design with 4 replications in loamy sand soil, having good-infiltration capacity. The treatment comprised, viz. control (conventional method), raised-bed method, ridge and furrow method, ditch method, conventional method with castor-shell mulch, conventional method with plastic mulch, raised-bed with castor-shell mulch, raised bed with plastic mulch, ridge and furrow method with castor-shell mulch, ridge and furrow method with plastic mulch, ditch method with castor-shell mulch, ditch method with plastic mulch. The results of pooled data of 3 years showed that, the conventional method with plastic mulch resulted in higher seed yield (1,943 kg/ha), followed by ridge and furrow method with castor-shell mulch and conventional method with castor-shell mulch. However, the higher rainwater-use efficiency (3.57 kg/ha-mm of water) was observed in the treatment of raised bed with plastic mulch. The magnitude of increase in seed yield in conventional method with castor-shell mulch over the control was 56.74% on pooled basis. Thus, use of castor-shell mulch or crop-residue as low-priced input in dryland farming may be encouraged for enhanced *in-situ* moisture conservation, castor-grain yield and rainwater-use efficiency.

Key words: Castor, Dryland agriculture, Land configuration, Mulching, Rainwater-use efficiency

Castor belongs to Euphorbiaceace family and its seed is the source of castor oil, which has a wide variety of uses. As of now, more than 95% of the total castor cultivated area is under hybrids. During 2019–20, castor was cultivated in an area of 0.97 million ha, with a production of 1.95 million tonnes and productivity of 2010 kg/ha. Gujarat and Rajasthan account for 92% of the total castor area under irrigated conditions, while an 8% of the total castor area is under rainfed conditions mainly distributed in the states of Telangana, Andhra Pradesh, Tamil Nadu etc. It is an important and popular oilseed crop grown under dryland condition in North Gujarat, India. The region falls under semi-arid condition. Hence, hot weather, low and erratic behaviour of rainfall causes early-or late-season drought. In order to mitigate adverse effect of drought certain moisture-conservation practices are required for successful cultivation of crops under aberrant weather conditions. The conservation of rainwater and its efficient use has been practiced in arid and semi-arid regions under dryland conditions with great success.

During the rainy season, heavy downpour at short span of time leads to water stagnation which affects the spike formation and capsule development of castor, thereby proper land-configuration practices are required for easy and uniform germination as well as growth and development of plants. Land configuration is the alternation of shape of seedbed and land surface which helps in infiltration of rainfall, minimizing erosion, preventing runoff, facilitates drainage and ultimately improves water-use efficiency (Singh *et al*., 2017). Land configuration can be considered as one of the most important management practices which increases input-use efficiency and crop production but, it primarily depends on soil type and rainfall received during the cropping period (Kamble *et al.,* 2016).

On the other hand, Mulch has a great role in soil moisture conservation by modifying microclimatic of soil. Mulching covers the soil to make more favourable condi-

[3]**Corresponding author's Email:** patelbrijal1994@gmail.com

[1,2]Associate Professor, [3]Young Professional-II, [4]Assistant Research Scientist, [5]Senior Research Assistant, Centre for Natural Resources Management, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat 385 506

tions for plant growth and development as well as efficient crop production. It helps prevent weed growth, reduce evaporation, and increase rainwater infiltration during the growing season, to reduce temperature fluctuations and to promote soil productivity (Sarolia and Bhardwaj, 2012). Different mulching methods, i.e. application of organic materials (crop residues) like castor-shell and plastic mulching, provide better environment to the plant. When compared to other mulches plastic mulch plays a positive role in crop growth, yield and water conservation by forming a completely impermeable to water mainly due to prevention of direct evaporation of moisture from the soil limiting the water losses and soil erosion over the surface. Therefore, conservation of soil-moisture by using organic mulching may be a ingenious alternative to raise productivity in dryland farming.

Keeping these points in view, the experiment was planned to find out the suitable mulch to check the soil-moisture losses through evaporation and conserve maximum *in-situ* moisture conservation for obtaining higher productivity in castor under dryland condition.

MATERIALS AND METHODS

The experiment was carried out during the rainy (*kharif*) season of 2016–2017 and 2018–2019 at the Centre for Natural Resources Management, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, (24° 19' N, 72° 19' E, of 154.52 m above the mean sea-level), Gujarat. The study area falls in North Gujarat Agro-climatic Region (Zone-IV). The soil was loamy sand, low in organic carbon (0.24%) and available nitrogen (145 kg/ha), medium in phosphorus (34 kg/ha) and potassium (165 kg/ha) status.

The standard week-wise meteorological data on seasonal rainfall and rainy days for the period of experimentation (2016, 2017 and 2018) recorded at the Meteorological observatory, Agronomy Instructional Farm, C.P. College of Agriculture, SDAU, Sardarkrushinagar are depicted in Fig. 1.

The experiment was laid out in a randomized block design with 12 treatments and 4 replications. The treatment comprised viz. control (conventional method), raised-bed method, ridge and furrow method, ditch method, conventional method with castor-shell mulch, conventional method with plastic mulch, raised-bed with castor-shell mulch, raised-bed with plastic mulch, ridge and furrow method with castor-shell mulch, ridge and furrow method with plastic mulch, ditch method with castor-shell mulch, ditch method with plastic mulch. All the treatments of land configuration were imposed before sowing, expect mulch materials were applied 10 days after the last effective rainfall of the season. The allotment of treatments to various plots in each replication was done by referring random number. Size of the gross plot was 6.0 m × 4.5 m. The field was prepared by carrying out ploughing, clod crushing and harrowing. Castor variety 'GCH 7' was sown with the seed rate 4 kg/ha at 90 cm × 60 cm spacing. The sowing of experiments was done at the onset of the monsoon, normally from the first week of July to the third week of July during all the years of experimentation. Fertilizer doses of 60–40 and 00 kg N, P_2O_5 and K_2O/ha were applied. Half dose of N (30 kg/ha), and full dose of phosphorous (40 kg/ha) was given at the time of sowing. Remaining N (30 kg/ha) was applied 45 days after sowing. The crop was raised with recommended package of practices. All the agronomic practices and need-based plant-protection measures were followed to keep crops free from pest and diseases.

In order to assess the impact of the treatments on growth and yield attributes such as castor seed and stalk yield, plant height, length of main spike, number of spikes/plant, and number of capsules/spike were recorded at periodical intervals and analyzed statistically by applying the tech-

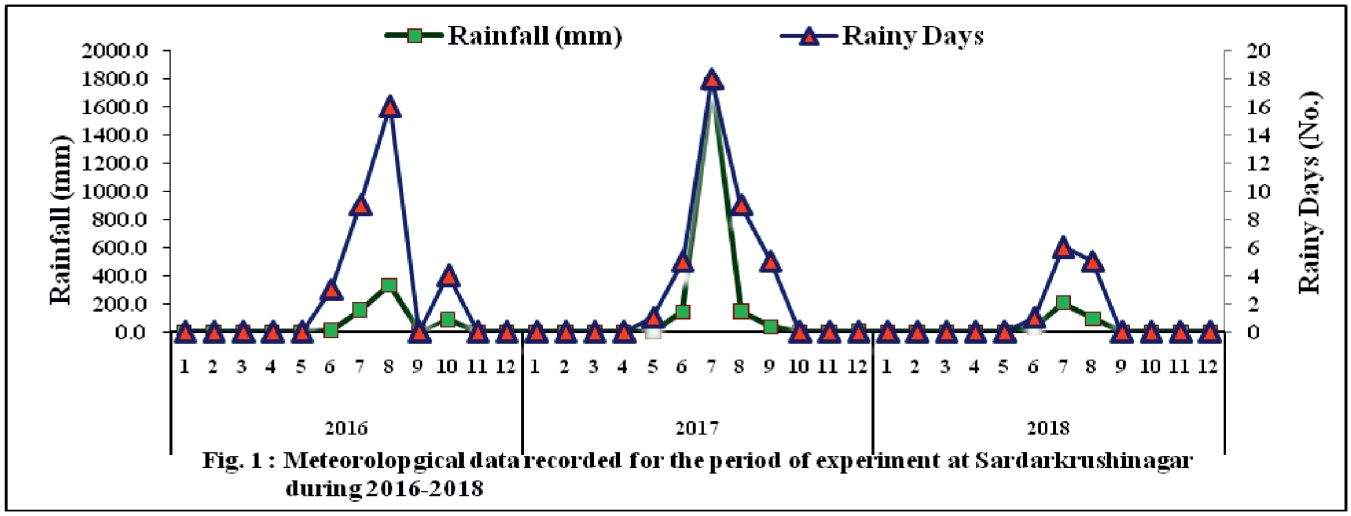

Fig. 1 : Meteorolopgical data recorded for the period of experiment at Sardarkrushinagar during 2016-2018

nique of analysis of variance (ANOVA) prescribed for design to test the significance of overall difference among treatments by the F test and conclusions were drawn at 5% probability level.

Rainwater-use efficiency

The rainfall is being regularly measured at the research farm of the centre using recording type rain gauge. Generally, the effective rainfall is being calculated by deducting the runoff generated during the rainfall event. In the present study, US Bureau of land reclamation method was considered for the estimation of the effective rainfall for loamy sand soil.

Operational energy

The energy consumption in agriculture is one of the key factors which affects the economics of cultivation. In present study, conventional fuel (diesel) was used as source of energy to perform farm operations using tractors. The operational energy for fuel consumed was calculated formulas:

$$\text{Operational energy (KWh/Ha)} = \frac{\text{Fuel consumption (lit/hr)} \times \text{Specific gravity of fuel} \times \text{Calculated value of fuel}}{860}$$

The rate of labour use in the castor production process was determined for each operation. The labour energy input (MJ/ha) at every stage in the production process was estimated by the following equation.

$$\text{LABEN} = [(\text{LABOUR} \times \text{TIME})/\text{Area}]\ \text{LABENF}$$

where LABEN, Labour energy (MJ/ha); LABOUR, number of working laboure; TIME, operating time, h; AREA, operating area, ha; LABENF, labour energy factor, MJ/h. The labour energy factor was considered 1.96 MJ/ha for manual labour (Safa and Tabatabaeefar, 2002).

RESULTS AND DISCUSSION

Effect of land configuration and mulching on growth and yield attributes

Plant height was significantly influenced by various land configuration and mulch treatments (Table 1). Among different treatments, conventional method with plastic mulch treatment recorded significantly higher plant height (136 cm) but was at par with T_5, T_8, T_9 T_{10} and T_{12} treatment in pooled results. This might be owing to maintain of proper air-moisture regimes under conventional method of sowing which improved supply of required moisture, available nutrients, soil aeration and better soil environment ultimately resulted in better growth and development of castor crop, while plastic mulching created a suitable condition for plant growth by influencing soil temperature, moisture retention, improved soil texture and microbial activities (Ghosh *et al.,* 2006). Sathiya *et al.,* (2020) also found that groundnut sown under raised bed and furrow (60 cm width and 30 cm furrow) system with polythene mulching resulted in significantly higher in plant height over other treatments.

The effect of different land configuration and mulch treatments were found to be non-significant for length of main spike on pooled data of 3 years.

The land configurations and mulch treatments significantly influenced the yield attributes, i.e. spikes/plant and capsules/spike in pooled results (Table 1). Treatment of conventional method with plastic mulch produced significantly higher number of spikes, but it was at par with T_9

Table 1. Effect of various land configuration and mulch treatments on growth attributes and yield attributes of castor (pooled data of 3 years)

Treatments	Plant height (cm)	Length of main spike (cm)	Spikes/ plant	Capsules/ spike	Seed yield (kg/ha)	Stalk yield (kg/ha)
T_1, Control (conventional method)	105	39	4.3	63	772	1103
T_2, Raised-bed method	119	42	5.2	71	966	1437
T_3, Ridge and furrow method	112	41	4.5	73	905	1265
T_4, Ditch method	124	40	5.5	77	974	1569
T_5, Conventional method with castor-shell mulch	135	43	5.5	85	1210	1678
T_6, Conventional method with plastic mulch	136	42	5.9	84	1300	1943
T_7, Raised bed with castor-shell mulch	124	43	5.8	76	1037	1594
T_8, Raised bed with plastic mulch	134	40	5.2	84	1228	1724
T_9, Ridge and furrow method with castor-shell mulch	128	42	5.9	75	1094	1683
T_{10}, Ridge and furrow method with plastic mulch	129	40	5.4	79	1035	1535
T_{11}, Ditch method with castor-shell mulch	125	39	5.3	73	1095	1571
T_{12}, Ditch method with plastic mulch	129	41	5.4	76	919	1453
SEm±	3.1	1.9	4.8	2.5	61.3	69.1
CD (P=0.05)	8.8	NS	0.2	7.2	180.0	192.7
Y×T	NS	NS	14.3	NS	NS	NS

and T_7 treatment in pooled results. Also, interaction effect of land configuration and mulching for number of spikes/plant was found significant in the pooled results.

Significantly more number of capsules/spike were observed under conventional method with castor-shell mulch but it was remained at par with T_6, T_8 and T_{10} treatments. The improvement in above parameters was mainly because of better plant growth under conventional method.

Effect of land configuration and mulching on yields

A marked effect of different treatments of land configuration and mulching on seed and stalk yields (kg/ha) was observed in the pooled results (Table 1). Treatment of conventional method with plastic mulch registered resulted in significantly higher seed (1,300 kg/ha) and stalk (1,943 kg/ha) yields in pooled results, but seed yield was at par with treatments T_8 and T_5. The magnitude of increase in seed yield in treatment of conventional method with plastic mulch over the control; was 68.39% followed by 59.74% and 56.74% in T_8 and T_5 treatments respectively. This might owing to the cumulative effect exerted from improvement in soil environment, aeration, root development, optimum moisture-air equilibrium throughout the crop-growth period, besides easy supply of available nutrients to the crop resulted in better growth and development which ultimately reflected in higher seed and stover yields, while plastic mulching which created a favourable micro-climatic condition for castor and moreover, reduced the crop-weed competition due to complete cover of the field. The results are in accordance with finding of Pramanik *et al.* (2009) and Jat *et al.* (2012). Our results confirm the findings of Dutta (2006), who stated that polythene-mulched groundnut gave significantly higher pod yield (3,097 kg/ha) over rice-straw mulch, rice-husk mulch and no-mulch treatment.

Effect of land configuration and mulching on rainwater-use efficiency

The year-wise rainwater-use efficience (RWUE) was calculated using the method described in methodology and treatment wise 3-year mean value is presented in Fig. 2.

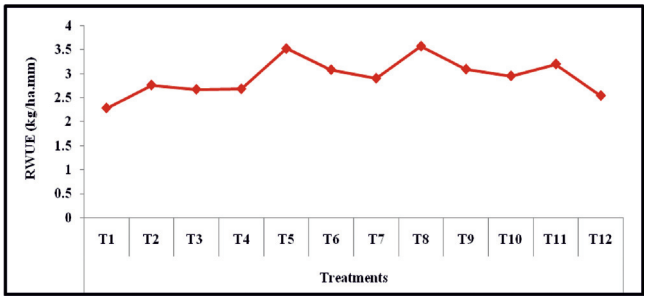

Fig. 2. Effect of land configuration and mulch treatments on rainwater use efficiency (pooled data of 3 years)

The RWUE was higher (3.57 kg/ha-mm) in raised-bed with plastic mulch treatment, followed by 3.52 kg/ha-mm in conventional method with castor-shell mulch treatment.

In-situ moisture conservation

The treatment-wise *in-situ* moisture conservation was examined by taking soil moisture content observations after harvesting of the crop. The soil-moisture content was determined by gravimetric method. It was observed that, placement of the castor-shell mulch was more convenient in conventional method treatment than treatments with land configurations affected on soil-moisture conservation. In treatment of raised bed with plastic mulch, higher mean moisture content (2.80%) was observed followed by treatment T_5 (2.69%) and T_6 (2.68%) treatments. Proper placement of castor-shell mulch and incorporation of organic matter (castor shell) in the soil might be the reason for better *in-situ* moisture conservation in treatment T_5 (conventional method with castor-shell mulch) as the experiment was conducted on same site. Jinger *et al.* (2017) also find that, land configurations, viz. ridge and furrow and bed systems have been known to be a more feasible and practicable proposition to conserve soil moisture and dispose of additional rainwater (runoff) in rainfed regions.

Energy requirement for farm operations

The operational energy for different treatments was calculated using the method described under Materials and Methods. The raised beds were constructed using the tractor-operated raised-bed planter, whereas ridge and furrow and ditch were constructed with cultivator using appropriate tools (tyne and blade). Use of tractor for land configuration needed additional fuel consumption. On the other, construction of land configurations and laying of castor-shell mulch averted interculturing operations increased the manual labour for weeding. The operational energy was found higher (2,000 MJ/ha) in treatments with raised-bed planter (T_7 and T_8). In treatment of conventional method with castor-shell mulch, the operation energy was found 1694 MJ/ha (Table 3).

Organic carbon

The organic carbon was found higher in treatments with castor shell mulch than rest of the treatments. The higher organic carbon was 0.33% in treatment of conventional method with castor-shell mulch, followed by ditch method with castor-shell mulch (0.31%), ridge and furrow method with castor-shell mulch (0.29%) and raised bed with castor-shell mulch(0.28%). Appropriate placement of castor-shell mulch in conventional method might have played vital role for proper incorporation and decomposition of organic matter resulted in higher organic carbon.

Table 2. Effect of land configuration and mulch treatments on economics of castor (pooled data of 3 years)

Treatments	Seed yield (kg/ha)	Stalk yield (kg/ha)	Gross income ₹/ha	Total cost ₹/ha	Net profit ₹/ha	Benefit: cost ratio
T_1, Control (conventional method)	772	1,103	31,432	12,350	19,082	2.55
T_2, Raised-bed method	966	1,437	39,359	16,950	22,409	2.32
T_3, Ridge and furrow method	905	1,265	36,833	16,950	19,883	2.17
T_4, Ditch method	974	1,569	39,745	16,950	22,795	2.34
T_5, Conventional method with castor-shell mulch	1,210	1,678	49,239	22,850	26,389	2.15
T_6, Conventional method with plastic mulch	1,300	1,943	52,972	40,350	12,622	1.31
T_7, Raised bed with castor-shell mulch	1,037	1,594	42,277	22,250	20,027	1.90
T_8, Raised bed with plastic mulch	1,228	1,724	49,982	42,250	7,732	1.18
T_9, Ridge and furrow method with castor-shell mulch	1,094	1,683	44,602	22,250	22,352	2.00
T_{10}, Ridge and furrow method with plastic mulch	1035	1,535	42,168	42,250	-83	1.00
T_{11}, Ditch method with castor-shell mulch	1095	1,571	44,586	22,250	22,336	2.00
T_{12}, Ditch method with plastic mulch	919	1,453	37,487	42,250	-4764	0.89

Table 3. Effect of land configuration and mulch treatments on operational energy, organic carbon and increase in yield over control (pooled data of 3 years)

Treatments	Castor seed yield (kg/ha)	Operational energy (kwh/ha)	Organic carbon (%)	Increase yield over control (%)
T_1, Control (conventional method)	772	1,537	0.23	-
T_2, Raised-bed method	966	1,843	0.26	25.13
T_3, Ridge and furrow method	905	1,769	0.21	17.23
T_4, Ditch method	974	1,769	0.24	26.17
T_5, Conventional method with castor-shell mulch	1,210	1,694	0.33	56.74
T_6, Conventional method with plastic mulch	1,300	2,000	0.20	68.39
T_7, Raised bed with castor-shell mulch	1,037	2,000	0.28	34.33
T_8, Raised bed with plastic mulch	1,228	1,926	0.21	59.07
T_9, Ridge and furrow method with castor-shell mulch	1,094	1,926	0.29	41.71
T_{10}, Ridge and furrow method with plastic mulch	1,035	1,926	0.22	34.07
T_{11}, Ditch method with castor-shell mulch	1,095	1,926	0.31	41.84
T_{12}, Ditch method with plastic mulch	919	1,926	0.24	19.04

Economics

Economics worked out on the basis of input cost and selling price of seed and stalk indicated that, the maximum net profit (₹26,389/ha) was recorded under treatment of conventional method with castor-shell mulch (Table 2). The benefit: cost ratio was recorded higher in treatments without mulch; however, net profit was lower in these treatments. Despite higher moisture conservation and grain yield in treatments with plastic mulch, the higher cost of plastic affected severely the economics of castor cultivation in dryland condition.

Castor is most preferred and better remunerative crop in dry land agriculture of North Gujarat. The improved varieties of castor crop response better to the enhanced soil moisture. With increased input cost in agriculture the economics of the dryland agriculture affected due to the uncertainty of moisture availability in semi arid tropics. The outcome of the experiment conducted for 3 years on dryland castor revealed that, *in-situ* moisture conservation certainly helps in increasing the grain yield of castor. However, the cost of farm operations for construction of land configuration and higher input cost of plastic material reduced the net profit. The operational energy was found higher in treatments with land configurations. Use of castor shell as mulch helped conserve moisture and ultimately increased net profit to 26,389 /ha. Therefore, the use of castor shell as low-priced mulch can be suggested to the farmers of the dryland conditions rather than black plastic mulch. The plastic mulch film has intimate contact with soil which may creates adverse effects on pathogen and reduce activity of soil micro-organisms. In light of present results obtained from the 3 years investigation, it is concluded to apply castor-shell mulch @ 5 t/ha nearly 10 days after the last effective rainfall of the season to get higher yield and economic return of castor ('GCH 7') under rainfed conditions. The castor-shell mulch is low-priced

and easily available, as castor is the major crop of the region where as black plastic mulch is costly and also hinders the infiltration if rainfall occurs after its application.

REFERENCES

Dutta, D. 2006. Studies on effect of planting method and mulch on summer groundnut (*Arachis hypogaea* L.). *International Journal of Agricultural Science* **2**: 441–443.

Ghosh, P.K., Dayal, Devi, Bandyopadhyay, K.K. and Mohanty, M. 2006. Evaluation of straw and polythene mulch for enhancing productivity of irrigated summer groundnut. *Field Crops Research* **99**: 76–86.

Jat, R.A., Arvadia, M.K., Tandel, B., Patel, T.U. and Mehta, R.S. 2012. Response of saline water irrigated greengram (*Vigna radiata*) to land configuration, fertilizer and farmyard manure in Tapi command area of south Gujarat. *Indian Journal of Agronomy* **57**(3): 270–274.

Jinger, D., Sharma, R.K., and Tomar, B.S. 2017. Moisture conservation practices for enhancing productivity in rainfed agriculture. *Indian Farming* **67**(6): 06–10.

Kamble, A.S., Waghmode, B.D., Sagvekar, V.V. and Navhale, V.C. 2016. Effect of land configuration and mulching on productivity and energy use in groundnut (*Arachis hypogaea*). *Indian Journal of Agronomy* **64**: 489–494.

Pramanik, S.C., Singh, N.B. and Singh, K.K. 2009. Yield, economics and water use efficiency of chickpea (*Cicer arietinum* L.) under various irrigation regimes on raised bed planting system. *Indian Journal of Agronomy* **54**(3): 315–318.

Safa, M. and Tabatabaeefar, A. 2002. Energy consumption in wheat production in irrigated and dry land farming. (In) Proceedings of International Agricultural Engineering Conference, Wuxi, China, 28–30 November, 2002.

Sarolia, D.K. and Bhardwaj, R.L. 2012. Effect of mulching on crop production under rainfed condition: A review. *International Journal of Research in Chemistry and Environment* **2**: 8–20.

Sathiya, K., Hussainy, S.A.H. and Sridhar, P. 2020. Effect of land configuration and mulching on the growth, yield and economics of groundnut (*Arachis hypogaea*). *Research on crops* **21**(2): 226–230.

Singh, A.K., Meena, R.N., Kumar, A.R., Sunil Kumar, Meena, R. and Singh, A.P. 2017. Effect of land configuration methods and sulphur levels on growth, yield and economics of Indian mustard (*Brassica juncea* L.) under irrigated condition. *Journal of Oilseed Brassica* **8**: 151–57.