

Response of rainfed Indian mustard to varying fertilizer levels under different land configurations

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Abstract

Aim: To study the effect of different land configurations and nutrient management practices on various yield attributes, yield and economics of Indian mustard (*Brassica juncea* L.).

Methodology: A field experiment was carried out at CCS Haryana Agricultural University, Regional Research Station, Bawal, laid out in split plot design during *rabi* 2020-21 and 2021-22 to study the effect of land configuration viz. Broad Bed (90 cm) and sowing was done in furrow; Ridge (90 cm) and sowing was done on ridge) and Conventional sowing in main plot and four nutrient management viz. 100% RDF (Recommended dose of fertilizers) + Biofertilizers (PSB + *Azotobacter*); 75 % RDF + FYM @ 10 t ha⁻¹; 75% RDF + FYM @ 10 t ha⁻¹ + Biofertilizers (PSB + *Azotobacter*) and 125% RDF + Biofertilizers (PSB + *Azotobacter*) under rainfed condition in Indian mustard.

Results: The present study revealed that among land configurations significantly higher seed (20.03 q ha⁻¹) and stover yield (48.54 q ha⁻¹) were recorded in broad bed and furrow as compared to ridge and furrow and conventional sowing. Among the nutrient management practices, significantly higher seed yield (20.89 q ha⁻¹ and 19.93 q ha⁻¹) were observed with the application of 125% RDF + Biofertilizers (PSB + *Azotobacter*) and 100% RDF + Biofertilizers (PSB + *Azotobacter*), respectively, over other treatments. These treatments were best in terms of yield and economics.

Interpretation: The results indicate that for better yield of Indian mustard, farmers should prefer broad bed (90 cm) and sowing should be done in furrow with an application of 125% RDF + Biofertilizers (PSB + *Azotobacter*) under rainfed conditions.

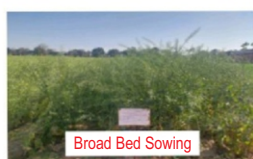
Key words: Biofertilizers, Indian mustard, Land configuration, Nutrient management

Experiment laid out in split plot design to study the effect of various land configurations and nutrient management on yield and economics of Indian mustard



Three sowing methods viz. Broad Bed (90 cm) and sowing was done in furrow, Ridge and Furrow (90 cm ridge) and sowing was done on ridge and Conventional sowing assigned to main plot.

Four nutrient combinations viz. 100% RDF + Biofertilizers, 75% RDF + FYM @ 10 t ha⁻¹, 75% RDF + FYM @ 10 t ha⁻¹ + Biofertilizers and 125% RDF + Biofertilizers allotted to the sub-plots



In Indian mustard, Broad Bed (90 cm) and sowing in furrow with application of 125% RDF+ Biofertilizers resulted in significantly higher yield and fetched highest net return.

Introduction

Edible oils are an essential part of the Indian diet, rapeseed-mustard is one of the nation's main oilseed crop and plays a significant role in Indian trade, industry and agriculture. Rapeseed-mustard holds a distinguished position and holds second place to groundnut among the nine major oilseed crops farmed in the nation: groundnut, rapeseed-mustard, linseed, sunflower, safflower, niger, soybean, sesame, and castor (Rohit et al., 2023). Indian mustard, also known as *Brassica juncea* L., is a vital source of mineral nutrition for humans and animals. India is the second largest rapeseed-mustard producer of the world, with one-fifth of the world's rapeseed-mustard production next to Canada (Rohit et al., 2023). The estimated area, production and productivity of rapeseed-mustard in the world was 36.59 million hectares (m ha), 72.37 million tones (mt) and 1980 kg ha⁻¹, respectively (Gandhimathy, 2022; Barik, 2023). Mustard production in the country during 2021-22 recorded 11.75 million tonnes from 8.06 million hectare area and productivity of 1458 kg ha⁻¹. Haryana holds second position after Rajasthan occupying 0.7 million hectare area and 1.37 million ton production (Rohit et al., 2023).

In modern agriculture, production practices mostly emphasize on wide spread use of chemical fertilizers for higher production but at the same time of chemical fertilizers deteriorate soil fertility and leads to ecological degradation continuous non-judicious use of chemical. The major constraint limiting the productivity of oilseeds is predominantly raised under energy-starved conditions (on poor fertile lands). Although several factors are responsible for low productivity mainly imbalance use of chemical fertilizers. To enhance the productivity of this crop, use of balanced fertilization by application of chemical fertilizers, manures along with biofertilizers viz., *Azotobacter* and phosphate solubilizing bacteria (PSB) is of great significance, in order to attain maximum economic yield without any deleterious effect on soil properties or ecological balance. Integrated use of organic and inorganic sources of nutrients can be an effective measure in boosting average yield of mustard (Kumawat et al., 2014).

Tillage is the initial operation in the cultivation of arable crops, traditionally involving primary (mould board plough), secondary (blade harrows) and tertiary (leveling) processes. As, conservation of moisture is most important for boosting agriculture productivity and enhancing the recovery of applied nutrients (Hari Om et al., 2013). Better plant growth and yield under broad beds can be attributed to improve nutrient availability due to adequate air and water movement under improved soil physical conditions. Both ridge-furrow and broad bed-furrow system of planting help in soil moisture conservation, soil aeration and synergistic effect on the availability of nitrogen and phosphorus. Therefore, a cautious management of soil moisture by *in-situ* conservation through proper land configurations can play vital role for easy and uniform germination as well as for better growth and development of mustard. Keeping the above facts in view, the present study was conducted with different land

configurations and nutrient management practices to estimate their effect on yield and economics of mustard under rainfed conditions..

Materials and Methods

Experimental site and climatic conditions: A field study was carried out at CCS Haryana Agricultural University, Regional Research Station, Bawal during *rabi* 2020-21 and 2021-22. Geographically, Bawal is located at 28.07° N and 76.59° E in western Haryana. It is situated in agroclimatic zone II (semi-arid region) of Haryana. The soil of experimental field was low in organic matter (0.21%) and available nitrogen (108.3 kg ha⁻¹) and medium in available phosphorus (12.6 kg ha⁻¹) and available potassium (168.6 kg ha⁻¹) with slightly alkaline in reaction (pH 8.1) at the initiation of the experiment. The total rainfall received during the crop season of 2020-21 and 2021-22 (October-March) was 68.6 and 196.5 mm with 9 and 16 numbers of rainy days, respectively. In this study, despite good crop growth yield level across the treatments in the year 2020-21 was slightly lower as compared to 2021-22. It was due to higher amount of rainfall received and more number of rainy events during the year 2021-22.

The experiment was laid out in a split plot design to judge the significant difference between the means of two treatments at higher precision as per the standard procedure of Panse and Sukhatme (1985). The three land configurations viz. BBF: Broad Bed (90 cm) and sowing was done in furrow), RF: Ridge and furrow (90 cm) and sowing was done on ridge) and Conventional sowing in the main-plots. Among the nutrient management four nutrient combinations viz. F₁: 100% RDF (Recommended dose of fertilizers) + Biofertilizers (PSB + *Azotobacter*), F₂: 75 % RDF + FYM @ 10 t ha⁻¹, F₃: 75% RDF + FYM @ 10 t ha⁻¹ + Biofertilizers (PSB + *Azotobacter*) and F₄: 125% RDF + Biofertilizers (PSB + *Azotobacter*) in sub-plots. The experiment site, located in the central plains of Haryana lies within India's Trans-Gangetic plains agro-climatic zone, has a tropical steppe and semi-arid climate. After the withdrawal of monsoon rains, the experimental field was ploughed using a tractor-drawn disc harrow.

Two rounds of harrowing were carried out for preparation of beds and for conventional sowing and to incorporate chipped crop residues and weeds, which helped break up clods and achieve good soil tilth, creating a finely pulverized seedbed ready for sowing during the 37th standard meteorological week. 100% (RDF) Recommended Dose of Fertilizer (40 kg N+20 kg P₂O₅ ha⁻¹) was applied at the time of sowing. Additionally, seed was treated with bio-fertilizers (PSB + *Azotobacter*) and a specific quantity of well-decomposed farmyard manure (FYM) was applied to the designated treatment plots prior sowing the crop. This manure was thoroughly incorporated into the soil to ensure proper nutrient distribution and to enhance soil fertility. Mustard variety RH 725 was grown as per land configuration treatments. Data recorded on growth, yield attributes and yields were subjected to statistical analysis and the mean differences were evaluated by critical difference test at 5% level of significance. The 'OPSTAT' software of

CCS Haryana Agricultural University, Hisar, India was used for statistical analysis (Sheoran et al., 1998).

Energy Indices: Energy balance on soil tillage and crop cultivation was determined by the methods explained by Hülsbergen et al. (2001). Energy equivalents of the inputs and outputs used in mustard crop production to evaluate the energy efficiency of the agricultural production are given in Table 1.

Input energy (MJ ha⁻¹): Energy Inputs (*E_{ti}*) were divided into two main groups; direct and indirect energy. Direct energy (*E_d*) consisted of fuel consumption and human labor and indirect energy (*E_i*) comprised of the energy used for machinery, fertilizer, herbicide and seed. In agricultural production systems, human labor energy is usually not taken into consideration for energy balance calculations (Borin et al., 1997; Hülsbergen et al., 2001), however, in this study, labor energy has been included in the calculations.

Direct energy: Direct energy (*E_d*) was calculated by the formula given below (Hülsbergen et al., 2001).

$$E_d = (HL \times E_{HL}) + (FC \times E_{FC})$$

Where, HL: Human labour; FC: Fuel consumption; *E_{HL}*: Energy equivalent of Human Labour and *E_{FC}*: Energy equivalent of fuel

Table 1: Energy equivalents of the inputs and outputs:

Particulars	Unit	Energy equivalent	References
A. Input			
Human labour	H	1.96	Tabatabaeefar et al. (2009)
Diesel Fuel	L	56.31	
Farm- Machinery	H	62.70	
Tractor	kg	68.4	
Threshers	kg	17.40	
Nitrogen	kg	78.23	Ali et al. (2013)
Phosphate	kg	13.07	
Potash	kg	6.70	Tabatabaeefar et al. (2009)
ZnSO ₄	kg	20.9	
Farm yard manure	kg	0.3	
Electricity	kw	11.93	
Seed (Wheat)	kg	14.70	Ali et al. (2013)
Seed (Mung bean)	kg	14.70	Ali et al. (2013)
B. Output			
Grain (Wheat)	kg	14.70	Ozkan et al. (2004)
Straw (Wheat)	kg	12.50	
Grain (Mung bean)	kg	14.70	Ali et al. (2013)
Stover (Mung bean)	kg	12.50	

Distribute the weight of the machinery equally over the total life span of the machinery (hours) for the particular operation of crop.

Indirect energy: Indirect energy (*E_i*) was calculated by the following formula (Hülsbergen et al., 2001):

$$E_i = ((ME \times E_{ME}) / (T \times E_{FC})) + (FE \times E_{FE}) + (HE \times E_{HE}) + (SE \times E_{SE})$$

In the formula, each addition component means the energies for machinery, fertilizer, herbicide and seed, respectively. The pertinent component values recommended for agricultural production used are as shown in the Table 1.

Total energy input: Energy input is obtained by the sum of direct energy and indirect energy. In calculating the input energy, energy required for storage and transportation was not taken into consideration. This input energy was calculated for each soil tillage for the crop.

$$E_{ti} = E_d + E_i$$

Output energy (MJ ha⁻¹): Energy output for mustard crop was obtained by the following formula (Tabatabaeefar et al., 2009; Ali et al., 2013):

$$E_o = E_g + E_s$$

While calculating the energy output, both grain (*E_g*) and straw (*E_s*) energy values were used.

Input-output energy ratio: Energy parameter input-output energy ratio in crop production were calculated as per Singh et al. (1997).

Specific energy (MJ kg⁻¹): Energy parameter specific energy used in crop production were calculated as per Singh et al. (1997).

Results and Discussion

While comparing the growth and yield attributes under different land configurations, it was observed that tillage practices influenced the yield attributes significantly. The perusal of pooled data in Table 2 depicted that significant difference was observed among different land configuration and nutrient management regarding yield attributes at maturity. A quick view of the data in Table 2 reveal that Broad Bed (90 cm) and sowing was done in furrow (BBF) and Ridge (90 cm) and sowing was done on ridge (RF) recorded significantly higher number of primary branches per plant and number of siliquae per plant over conventional sowing. The numbers of siliquae per plant were higher to the tune of 5.3 and 17.3 per cent under BBF over RF and conventional sowing, respectively. However, siliqua lengths, number of seeds per siliqua and 1000-seed weight were not significantly influenced by different land configurations.

Increased biological activity in the soil, particularly that of organisms that fix atmospheric nitrogen, is the result of pulverization (caused by plowing) that allows oxygen and water to

Table 2: Effect of land configurations and nutrient management on yield attributes and yield of Indian mustard (pooled mean of 2 years).

Treatments	Number of primary branches per plant	Number of siliquae per plant	Siliqua length (cm)	No. of seeds per siliqua	1000-seed weight (g)
Land configurations					
BBF	4.63	299	4.11	11.68	4.86
RF	4.49	284	4.05	10.91	4.77
Conventional sowing	4.42	255	4.06	10.73	4.70
CD (p=0.05)	0.07	2.5	NS	NS	NS
Nutrient management					
F ₁	4.62	310	4.06	11.32	4.91
F ₂	4.30	222	4.01	10.80	4.66
F ₃	4.42	262	4.09	10.93	4.67
F ₄	4.73	322	4.13	11.39	4.85
CD (p=0.05)	0.12	15.3	NS	NS	NS

Table 3: Effect of land configurations and nutrient management on yield and economics of Indian mustard (pooled mean of 2 years).

Treatments	Seed yield (q ha ⁻¹)	Stover yield (q ha ⁻¹)	Gross returns (₹ ha ⁻¹)	Net returns (₹ ha ⁻¹)	B:C ratio
Land configurations					
BBF	20.03	48.54	99585	65766	2.96
RF	17.64	39.44	87526	53708	2.60
Conventional sowing	17.51	38.77	86858	57094	2.92
CD (p=0.05)	1.44	2.27	-	-	-
Nutrient management					
F ₁	19.93	43.48	98840	68195	3.22
F ₂	16.05	36.12	79628	46726	2.42
F ₃	16.70	41.57	82970	50013	2.52
F ₄	20.89	47.83	103854	70491	3.13
CD (p=0.05)	3.34	5.11	-	-	-

BBF: Broad bed (90 cm) and sowing in furrows, RF: Ridge and furrow (90 cm) and sowing on ridge, F₁: 100% RDF + Biofertilizers (PSB + *Azotobacter*), F₂: 75% RDF + FYM @ 10 t ha⁻¹, F₃: 75% RDF + FYM @ 10 t ha⁻¹ + Biofertilizers (PSB + *Azotobacter*), F₄: 125% RDF + Biofertilizers (PSB + *Azotobacter*)

freely circulate. (Rashidi and Abbassi, 2010). As a result, a biological environment in the soil that can convert soil nitrogen at rates appropriate for crop needs and effective physiological processes within the plant—achieved by various tillage techniques—will eventually result in increased plant development. (Usman et al., 2014). Cumulative effect of improved growth parameters (dry matter accumulation) through efficient metabolic activity, increased the photosynthetic rate, and supply of photosynthates from source to sink had accommodated more number of siliquae per plant under treatment F₄. These results are in line with those of Byomkesh et al. (2014).

Among nutrient management, treatment F₄ recorded significantly higher number of primary branches per plant and number of siliquae per plant over the remaining treatments but

remained at par with F₁ treatment. The number of siliquae per plant were higher to the tune of 22.9, 45.0 and 3.9 per cent under F₄ over F₃, F₂ and F₁, respectively. No significant differences were found among various nutrient treatments with respect to siliqua length, number of seeds per siliqua and 1000- seed weight. Since nitrogen is regarded as a growth ingredient, enhanced meristematic activities combined with enough photosynthetic availability due to effective physiological processes overall result in higher growth and its characteristics. Similar effects of tillage practices on growth of pearl millet crop has been reported (Usman et al., 2014; Mahala et al., 2006; Satyajeet et al., 2007b).

Yield is expressed as the cumulative function of the factors which contributes to it. The source-sink connection and the many sink components—such as the number of major

branches per plant, siliqua length, the number of siliquae per plant, and the weight of 1000 seeds—determine the crop plants' economic production. The pooled of data 2020-21 and 2021-22 (Table 3) revealed that among the land configurations, the grain and stover yield of mustard (20.03 and 48.54 q ha⁻¹) was significantly higher under BBF over RF (17.64 and 39.44 q ha⁻¹) and conventional sowing (17.51 and 38.77 q ha⁻¹) which was 13.5 and 23.1 % higher over RF and 14.4 and 25.2 % higher over conventional sowing in respect of grain and stover yield, respectively. Beneficial effects of tillage in terms of mineralization of nutrients and suppressing weed growth may also have positively impacted the stover yield. The superiority of ridge and furrow sowing over flat sowing could be ascribed to conservation of moisture that led to better development of yield attributes, which in turn increased the yield of mustard. Lower yield in RF as compared to BBF treatment may be due to comparatively smaller furrow and bed dimensions, while that in case of RF treatment can be ascribed to moisture stress faced by the two middle rows, during rhizome formation and development stage owing to inadequate horizontal movement of water from furrow to the centre of wider beds (Prabhakar et al., 2019).

Among nutrient management, F₄ treatment recorded significantly higher seed yield (20.89 q ha⁻¹) of mustard over the remaining treatments but remained at par with F₁ (19.93 ha⁻¹) treatment. The seed yield was higher to the tune of 25.1, 30.2 and 4.8 per cent under F₄ over F₃, F₂ and F₁, respectively. Similar trend was observed in stover yield. Further, FYM acts as a nutrient reservoir and upon decomposition produces organic acids, thereby absorbed ions are released slowly during the entire growth period of the crop leading to improvement in different yield components thereby, resulting in higher seed yield. *Azotobacter* is a non-symbiotic nitrogen fixing agromicrobe having potential to fix considerable quantities of atmospheric nitrogen in the rhizosphere of non-legumes. Significant growth and yield response to higher levels of fertilizer application might be attributed to increased availability and uptake of nutrients by crop plants which takes part in metabolism of plant as an activator of several enzymes and in turn may directly or indirectly affect the synthesis of carbohydrate and protein (Prabhakar et al., 2019; Aryan and Singh, 2000).

The perusal of data presented in Table 3 indicates that gross return (₹ 99585 ha⁻¹) and net returns (₹ 65766 ha⁻¹) were obtained highest in BBF, which was higher over RF and conventional sowing. Net return in BBF was higher to the tune of 22.5 and 15.3 % over RF and conventional sowing, respectively. The B:C ratio was highest in BBF (2.96) over RF (2.60) and conventional sowing (2.92). This is attributed to higher grain yield of mustard under this treatment. These results are in conformity with the previous reports (Jakhar et al., 2006; Sharma et al., 2008; Katiyar et al., 2017). More and less similar results due to integrated nutrient management have been documented by Satyajeet et al. (2007a). Among the nutrient management practices, higher gross returns of ₹103854 ha⁻¹ was incurred in F₄ treatment over other treatments. Similar trend was found in case of

net returns (₹ 70491 ha⁻¹). However, in case of B:C ratio, the highest (3.22) was computed under F₁ treatment. Gross return values are attributed to seed and stover yields, while net return values are affected by both gross return and total cost of crop cultivation with different nutrient managements (Singh et al., 2022).

Land configuration did not differ significantly among themselves with respect to available N, P and K (kg ha⁻¹) in soil at the time of harvest. A thorough understanding of data reveals that nutrient management treatments showed significant difference with respect to available NPK in the soil which were recorded significantly highest under F₄ treatment over the remaining treatments (Table 4). According to Kumar et al. (2024), application of higher dose of phosphorus recorded a higher available N, P and K in the soil. Treatment where RDF was applied in conjunction with farm yard manure and/or biofertilizers analyzed higher available NPK in soil. It was because adding chemical fertilizer and organic manures often alters the soil's chemical, biological, and physical characteristics. The inclusion of farm yard manure may be the cause of increase in variable N P and K because organic manure is essential for crop transformation, cycling, and nutrient availability, using it in combination with chemical fertilizer helps to stabilize production and enhance the chemical and physical characteristics of soil (Satyajeet et al., 2007b; Das et al., 2010; Kumar et al., 2018; Abdhesh et al., 2020).

Rain water use efficiency (RWUE) (19.96 kg ha⁻¹ mm) was recorded highest under BBF, which was higher over other treatments (Table 4). The water-use efficiency was lowest under conventional sowing (17.47 kg ha⁻¹ mm), which might be attributed to improved shoot and root growth of plants and significant increase in grain yield. Among nutrient management practices the highest RWUE (20.63 kg ha⁻¹ mm) was recorded under F₄ treatment as compared to other treatments, which may be attributed to higher seed yield of mustard under this treatment due to the provision of furrow holding good amount of rainfall events received during crop growth period. Patil et al. (2015) also reported that compartmental bunding and ridges and furrows conserved more rainwater in profile, thus producing higher sunflower seed yields varying from 22 to 28% compared to farmers' practice of flat-bed sowing. Planting pigeonpea with ridges and furrows also increase water use efficiency (Jat et al., 2000; Katiyar et al., 2017).

When considering the usage of natural resources and greenhouse gas emissions, energy is crucial to sustainable development (Singh et al., 2024). Energy consumption has been steadily rising due to economic progress and population growth. Approximately, 14% of greenhouse gas emissions worldwide are attributable to agriculture. The evolution of more energy is needed for agricultural production in order to run machinery and equipment, support the production process, and create fertilizer and chemicals. Table 5 provides an analysis of energy data, including input energy, net energy, input-output energy ratio, specific energy, and energy productivity, for the mustard cultivation. Among land configuration, BBF had markedly higher

Table 4: Effect of land configurations and nutrient management on available N P K of soil at harvest and rain water use efficiency (pooled mean of 2 years).

Treatments	N (kg ha ⁻¹)	P (kg ha ⁻¹)	K (kg ha ⁻¹)	RWUE (kg ha ⁻¹ - mm)
Land configurations				
BBF	110.07	14.04	174.80	19.96
RF	110.43	14.29	174.79	17.63
Conventional Sowing	110.60	14.26	174.82	17.47
CD (p=0.05)	NS	NS	NS	-
Nutrient management				
F ₁	109.05	12.15	173.93	19.91
F ₂	106.63	10.55	170.38	16.04
F ₃	111.03	15.38	175.70	16.83
F ₄	114.75	18.71	179.21	20.63
CD (p=0.05)	1.58	1.14	2.43	-

Table 5: Effect of different treatments on energy input and output in mustard

Treatments	Input energy (MJ ha ⁻¹)	Net energy (MJ ha ⁻¹)	Input-output energy ratio (%)	Specific energy (MJ kg ⁻¹)	Energy productivity (kg MJ ⁻¹ ha ⁻¹)
Land configurations					
BBF	7.76	72.09	10.29	4232	0.78
RF	7.76	72.09	10.29	4232	0.78
Conventional Sowing	7.11	72.74	11.24	3873	0.85
CD (p=0.05)	-	-	-	-	-
Nutrient management					
F ₁	7.75	75.90	10.81	3888	0.82
F ₂	6.91	61.83	9.97	4306	0.76
F ₃	6.91	69.60	11.09	4139	0.84
F ₄	8.60	81.90	10.54	4115	0.80
CD (p=0.05)	-	-	-	-	-

BBF: Broad bed (90 cm) and sowing in furrows, Ridge and furrow (90 cm) and sowing on ridge, F₁: 100% RDF + Biofertilizers (PSB + *Azotobacter*), F₂: 75% RDF + FYM @ 10 t ha⁻¹, F₃: 75% RDF + FYM @ 10 t ha⁻¹ + Biofertilizers (PSB + *Azotobacter*), F₄: 125% RDF + Biofertilizers (PSB + *Azotobacter*)

value (7.76 MJ ha⁻¹ and 4232 MJ kg⁻¹) of input energy and specific energy, than RF and conventional sowing whereas the net energy (MJ ha⁻¹), input-output energy ratio and energy productivity (kg MJ ha⁻¹) was computed highest under conventional sowing.

Various fertility levels resulted in marked increase (8.60 and 81.90) in input energy (MJ ha⁻¹) and net energy (MJ ha⁻¹) highest being with F₄ treatment, followed by F₁, F₂ and F₃ respectively. However, input-output energy ratio (10.81 %) and energy productivity (0.84 kg MJ ha⁻¹) was recorded highest under F₁ and F₃ treatments, respectively. It may be noted that for energy inputs, the value of seed, fertilizers, harvesting, manual sowing and threshing were common to all combination of treatments and only variable factor was tillage plus inter-cultural operations. More and less similar results due to tillage practices have amply been

documented by Singh *et al.* (2024). Sidhpuria *et al.* (2014) reported that a major part of energy input was constant and it was 89 to 93 per cent of the total energy inputs. It meant that by variation in less than 10 per cent of the total energy input for rainfed pearl millet, the gain in energy output was 30-40 per cent over no tillage treatment. It is well known that weeds compete with main crop for moisture and nutrition, as moisture is a limiting factor under such conditions, any stress would severely hamper the ultimate yields. Low yields and poor energy efficiency in this particular treatment brings forth the importance of weed management under dryland conditions. Energy input-output analysis for millet production in semi arid zone of Nigeria, Abubakar and Ahmad (2010) reported that in all farm sizes, tillage and weeding consumed the highest energy as a result of low chemical usage. Their results further indicated that farms 2 to 4 ha

area were using energy more efficiently, while small farms showed lowest efficiency (ratio of 0.8) due to higher human and or animal energy component.

On the basis of two year study, it can be concluded that crop yields from rainfed mustard can be improved by adopting Broad bed (90 cm) and sowing in furrows with efficient conservation of soil moisture at root zone and duly increasing the fertilizer dose to 125% RDF along with seed treatment with biofertilizers. This recommendation addresses that land configuration and revision of fertilizer dose needs a relook for rainfed areas, especially in low and medium rainfall zones.

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