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CROP ESTABLISHMENT METHODS INFLUENCE PRODUCTIVITY AND PROFITABILITY OF SORGHUM-MUSTARD AND OTHER MUSTARD- BASED SYSTEMS IN SEMI-ARID ENVIRONMENT

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SUMMARY

Indian mustard [*Brassica juncea* (L.) Czern & Coss] is the predominant oilseed crop in semi-arid India, conventionally grown by repeated plowings during the rainy seasons to conserve soil moisture in fallow fields. To evaluate the effect of crop establishment methods on productivity, soil health and economics of mustard under sorghum-mustard, mung – mustard and fallow mustard cropping systems, a field experiment was conducted during 2018-19 at the agronomy Research farm area, CCS HAU, Hisar, India. The mean mustard seed yield increased 4.67 and 1.47 % compared to conventional tillage. The mean seed yield of *kharif* mung bean were also recorded higher by 29.79 and 48.46 % compared to conventional tillage. Fodder sorghum yields higher in case of conventional tillage. The interaction effect showed that TSGY was maximum in M- M system (3506 kg/ha) followed by S- M (2792 kg/ha) under bed planting which were additional yield from *kharif* season to farmer's compared to zero yield in traditional Fallow-mustard system. The ridge planting in Mung-Mustard cropping system accrued maximum net return across the tillage.

Key words: Agro-ecological adaptation, sustainable agriculture, semi-arid, sorghum-mustard CS

Haryana, in north-western India, faces water scarcity, declining soil fertility, and intensive monocropping, which challenge sustainable agriculture. In this region, mustard (*Brassica juncea* L.) serves as a principal oilseed crop during the *rabi* season. It is commonly cultivated after *kharif* cereals such as sorghum (*Sorghum bicolor* L.), pearl millet (*Pennisetum glaucum* L.), and mung bean (*Vigna radiata*). Mustard-based cropping systems play a significant role in providing food, fodder, and income in rainfed and partially irrigated regions of the state. The sustainable intensification of cropping systems is essential to guarantee food, fodder, and income security in semi-arid areas. These regions frequently experience irregular rainfall, low soil fertility, and limited water availability, which significantly hamper agricultural productivity (Yadav *et al*., 2024). Among various cropping systems, sorghum-mustard and other mustard-based rotations have shown great promise due to their adaptability, efficient use of resources, and positive impact on soil health. Nevertheless, the success of these systems is largely contingent upon the implementation of suitable crop establishment methods, which play a critical role in determining crop growth, resource efficiency, and ultimately, economic profitability. Crop establishment methods significantly enhance system performance by affecting seedling emergence, moisture conservation, weed suppression, and nutrient dynamics (Jat *et al*., 2020). Techniques like zero tillage, raised bed planting, and strip tillage improve water use efficiency and profitability over traditional methods. Rapeseed-mustard is the world's third most important source of edible oil, following soybean (*Glycine max* (L.) Merr.) and p*alm (Elaeis guine*ensis Jacq.). In India, rapeseed-mustard accounts for 22.2% of the total area and 22.6% of the total production under the nine oilseed crops grown (Shekhawat *et al.*, 2012). Indian mustard [*Brassica juncea* (L.) Czern & Coss] accounts for over 85% of the area cultivated with rapeseed–mustard in India. The cultivation of rapeseed-mustard predominantly occurs in marginal areas, where productivity is hindered primarily by low soil organic matter (SOM) and the limited resources available to farmers (Kumar, 2012). The national productivity of rapeseed-mustard remains at 1264 kg/ha due to limited irrigation, low input, and poor management skills. Improper land preparation, subpar crop establishment, excessive traffic, and persistent mono-cropping degrade soil fertility and increase cultivation costs (Wang *et al*., 2007; Simmons & Coleman, 2008; Helgason *et al.*, 2009). Systematic studies assessing the impact of these methods on both productivity and profitability of sorghum-mustard and other mustard-based cropping systems in semi-arid environments are currently sparse. Therefore, this research aims to evaluate the comparative advantages of various establishment techniques about yield, input use efficiency, and economic returns.

MATERIALS AND METHODS

The experimental site

The field experiment was conducted during 2018-19 at the Department of Agronomy, Research farm area of CCS HAU, Hisar, Haryana, India (29°10' N, 75°46' E, elevation 215.2 m). The region has a semi-arid climate with extreme temperature variations, ranging from sub-zero levels in winter to 45°C in summer. The annual rainfall is approximately 450 mm, with 70-80% occurring during the monsoon (July–September). The weekly meteorological data of crop season *kharif* 2018 and *rabi* 2018-19 of the experimental area is depicted in Fig 1. The study revealed that weekly average maximum and minimum temperature varied from 14.6 p C (January) to 32.2 p C (October) and 3.6 p C (January) to16.5 p C (November) respectively during the crop season. Relative humidity (RH) during morning ranged from 84.7 to 100% and during evening ranged from 46.4 to 85%.

Experimental detail

The experiment comprised of 3 tillage (permanent bed planting, ridge planting and conventional) and 3 mustard based cropping systems [mung bean-mustard, sorghum-mustard and fallow-mustard] in factorial randomized block design. Thus, a total of 9 combinations were allocated in RBD replicated thrice in permanent plots. Both *kharif* and *rabi* season crops were nourished with their respective recommended dose of fertilizers.

Crop establishment

The experiment was initiated with ploughing to break hard pen and leveled. The *kharif* season crops were sown as per standard recommendation. The raised beds were prepared and sown the crop simultaneously with raised bed planter attached with seed cum fertilizer drill. In permanent bed, crops were sown with bed planter attached with seed cum fertilizer drill. The conventional tillage crops were sown after tillage operations like harrowing (1), cultivator (3), rotavator (1) and leveling (1).

Crop yield and system productivity: Each crop harvested manually from the net plot area. The harvested produce was sun dried and threshed. The system productivity of different cropping systems was measured in mustard equivalent yield (MEY) and total system yield by converting yield of different crops using equations such as:

$$\text{MEY}\left(\frac{\text{Kg}}{\text{ha}}\right) = \left(\text{yield of kharif crops}\left(\frac{\text{kg}}{\text{ha}}\right)\text{X MSP of kharif Crops}\right)/\text{MSP of mustard crop}$$

Total system grain yield (kg/ha) = Mustard equivalent yield (kg/ha) + Mustard seed yield (kg/ha)

Economics: The economics analysis was worked out for all the cropping systems under the respective treatments. The total cost of cultivation includes all the input and related costs viz. field, labor,

TABLE 1
Effect of sowing methods and cropping system on yield of mustard and cropping system

Treatments	Mung seed yield (kg/ha)	Sorghum fodder yield (kg/ha)	Mustard yield (kg/ha)	Mustard equivalent yield (kg/ha)	Sorghum+Sorghum equivalent (kg/ha)	System yield (kg/ha)
Tillage						
Ridge	549	18642	2487	733	24638	2976
Conventional	423	22020	2376	679	22812	2829
Bed planting	628	19890	2411	817	27466	2956
CD at 5%	-	-	NS	50	1690	84.0
Cropping system						
M-M	533	-	2472	886	29760	3357
S-M	-	20184	2113	601	20184	2813
F-M	-	-	2589	-	-	2589
CD at 5%	-	-	72	22	753	74.0

TABLE 2

Effect of sowing methods and cropping system on moisture content and economics of mustard based cropping system

Treatments	SMC (%) at Sowing of *Rabi*	SMC (%) at harvest of *Rabi*	System GR (Rs/ha)	Net return (Rs/ha)	B:C
Tillage					
Ridge	9.89	11.55	124971	85831	2.39
Conventional	9.56	10.77	118802	80077	2.26
Bed planting	9.78	10.96	124151	85009	2.35
CD 5%	-	-	3553	3538	NS
Cropping system					
M-M	9.78	11.41	141010	93763.34	1.98
S-M	9.70	10.18	118162	73220.16	1.63
F-M	9.75	11.69	108752	83932.50	3.38
CD 5%	-	-	3103	3103	0.10

and electricity etc., are involved from sowing to harvesting. Gross returns were calculated by multiplying the crop yield with minimum support price that were offered by the Govt. of India (0). The net returns were calculated as the difference between the gross return and the total cost. The system net return was calculated by adding net returns of crops harvested within an individual calendar year.

Statistical Analysis: Sorghum-Mustard along with other cropping system yield and parametric data were all subjected to a two-way analysis of variance (ANOVA). We utilized OPSTAT software to compare treatment means that were statistically significant at the 5% probability level, developed by Department of Statistics at CCS HAU (Sheoran *et al*., 2020; Nagora *et al*., 2025 and Shweta *et al*., 2025).

RESULTS AND DISCUSSION

Seed yield of crops: The tillage does not influence seed yield of mustard significantly during study, however *kharif* crops yield increased markedly. Ridge planting recorded highest mustard seed yield and lowest in conventional tillage. The mean mustard seed yield increased 4.67 and 1.47% compared to conventional tillage. The mean seed yield of *kharif* mung bean were also recorded higher by 29.79 and 48.46 % compared to conventional tillage. Fodder sorghum yields higher in case of conventional tillage. Ridge and Bed planting improved yield of crops in the system due to better plant establishment, root development, optimum fertilizer placement, and improved soil physicochemical and biological properties. Higher productivity and profitability in CA-based management was reported in mustard (Jat *et al*.,2024).

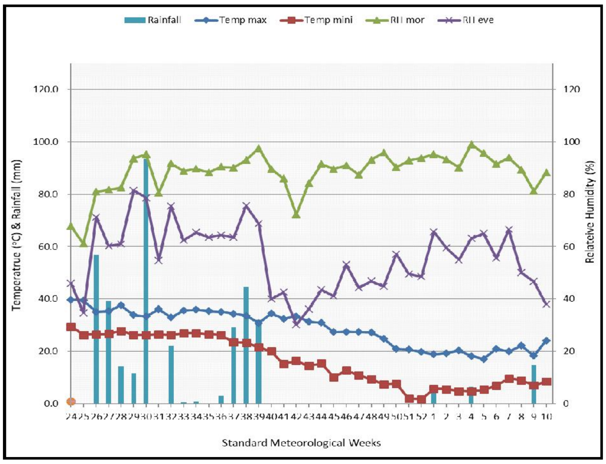

Fig. 1. Weekly weather parameters during the crop season (2018-19).

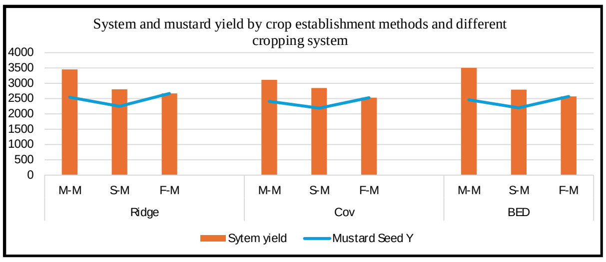

Fig. 2. Mustard and system yield under different establishment methods and cropping system.

Diversification of traditional fallow-mustard system with *kharif* mung bean and sorghum followed by mustard was investigated. The highest mustard yield higher in M-M cropping system (Table 1 and Fig. 2) This might be due to favourable soil-plant-environment continuum resulted into higher biomass and system yield.

Effect on SEY, MEY and TSGY: The Sorghum equivalent yield along with sorghum yield was significantly higher in bed planting system. The *kharif* season crop yield in term of sorghum higher in

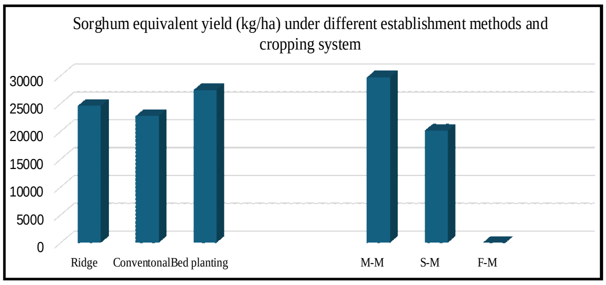

Fig. 3. Sorghum equivalent yield (kg/ha) under different establishment methods and cropping system.

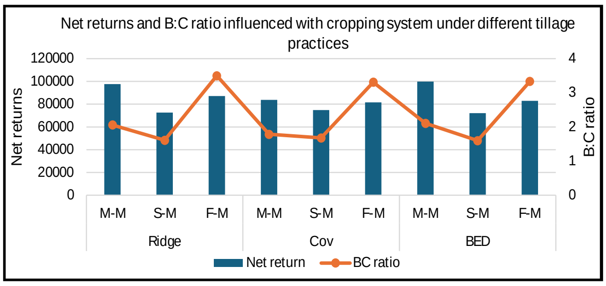

Fig. 4. Net returns and B:C ratio influenced with cropping system under different tillage practices.

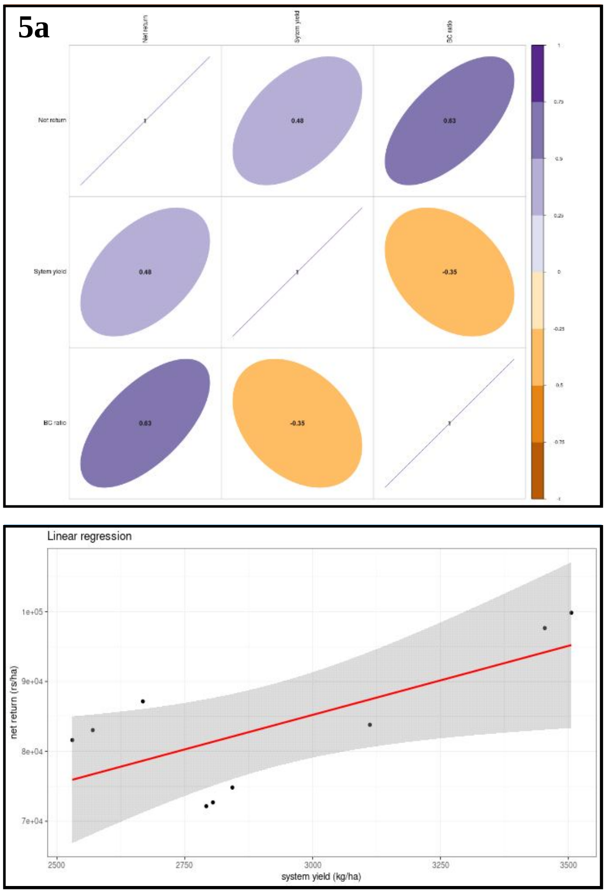

Fig. 5. (a) Correlation between system yield, net return and B: C, (b) Linear regression between system yield and net return of mustard based different cropping system in crop establishment methods.

bed planting system. The mustard equivalent yield of *kharif* crops significantly higher in the bed planting system, followed by ridge tillage. The mean MEY increased by 20.32 and 7.95 % in bed planting and ridge tillage over to conventional, respectively. Among the cropping system M-M cropping system recorded highest MEY and TSGY.

The interaction effect showed that TSGY was maximum in M- M system (3506 kg/ha) followed by S- M (2792 kg/ha) under bed planting which were additional yield from *kharif* season to farmer's compared to zero yield in traditional Fallow-mustard system (Fig. 2).

Economic returns: The net return and the benefit cost ratio were influenced markedly with tillage and cropping systems (Table 2 and Fig. 4). Ridge planting recorded maximum net returns across the cropping systems followed by bed planting and lowest in conventional planting. The ridge planting in Mung-Mustard cropping system accrued maximum net return across the tillage.

CONCLUSION

Crop diversification shown the capacity to adjust to the changing climate while enhancing productivity and profitability. Conservation tillage in mustard-based cropping systems shown superior results in enhancing yields for both *kharif* and *rabi* crops, as well as overall system productivity. This climate-smart approach to crop diversification promotes a novel paradigm for the sustainable and ecological development of mustard-based production systems.

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