



Agronomic evaluation of mustard planter for enhancing production efficiency of Indian mustard (*Brassica juncea*)

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ABSTRACT

Indian mustard [*Brassica juncea* (L.) Czern & Coss.] is traditionally sown either by broadcasting or with ordinary wheat seed drill having drawbacks of high seed rate, seed breakage, less seed germination, uneven and dense plant population resulting into low seed yield. A Mustard Planter was developed and evaluated at research station as well as farmers' field against wheat seed drill (farmer's practice) during 2016–18 to vanquish the pre-taxed constraints in Indian mustard. Results showed significant improvement in branches per plant, girth of basal node, leaf area index (LAI), relative water content (RWC), seed yield, harvest index, test weight and accrued higher benefit margin in the station trials. Farmer's field trials also recorded optimum plant population, higher plant height, branches per plant and stem girth. Mustard Planter sown crop recorded more seed yield (+9-22%), harvest index (+11.7%), Test weight (+13.6%), net return (+13.3-30.6%) and B/C ratio (+16%) in the station as well as farmer's field trials. The fields sown with Mustard Planter also conserved soil moisture (>100%) over wheat seed drill in 0-60 cm soil depth during the crop mid-season. The results endorsed that the Mustard Planter is an efficient seeding machine for sowing of rapeseed-mustard in the rainfed situation and may be recommended for its wider adaptability in the region for the benefit of the farmers.

Keyword: Economics, Evaluation, Growth, Indian mustard, Mustard Planter, Yield

Indian mustard [*Brassica juncea* (L.) Czern & Coss.] is foremost winter oilseed crop of India stand third in production after soybean and groundnut while first in edible oils. Since, the crop is cultivated mainly in the rainfed and resource scarce regions of the country, their contribution to livelihood security of small and marginal farmers' credence is very high. Despite being the third largest producer (11.3%) of oilseed brassica after Canada and China in the world, India meets 57% of the domestic edible oil requirements through imports (Jat *et al.* 2019). Oilseed brassica achieved significant growth in the past, however, the productivity levels are still low owing to large cultivation under biotic and abiotic stresses, and resources crunched regions. Besides the prevailing natural environment, sub-standard crop establishment technique in rapeseed mustard is the primary deterrent to realize its potentiality. Farmers generally practice sowing by broadcasting or with traditional wheat seed drill which led to uneven sowing depth, higher seed rate, breakage of seeds, less seed germination, uneven and

higher plant population, early exhaustion of soil moisture, more diseases and pests, weak plant growth, less branches, less siliquae and ultimately lesser seed yield. The competitive ability of mustard plant depends greatly upon the density of plants per unit area and soil fertility status (Rajput 2012, Shekhawat *et al.* 2012, Harikesh *et al.* 2017). Crop establishment at optimum plant population by maintaining proper row and plant geometry is important to secure a better translocation of photosynthates which render better yield of crop (Alam 2004). Sub-optimal planting geometry increases the inter and intra plant competition leading to poor growth and development, and seed yield in mustard crop. Sowing of Indian mustard at 40-45 cm row to row spacing found optimum for proper crops geometry ensuing better crop growth and development, resource utilization and ultimately less cost and high profit margins (Singh and Prasad 2003, Ram *et al.* 2008, Kumari *et al.* 2012).

To address these issues, a Mustard Planter performance was evaluated at research as well as farmer's field for various growth and yield parameters and economics under the present study.

MATERIALS AND METHODS

The experiments were conducted in Bharatpur located at 77°3' E longitude, 27°15' N latitude and at an altitude of 178.37 m amsl. The region falls under Agro climatic Zone IIIa (semi-arid Eastern plain) of Rajasthan with sub-tropical

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and semi-arid climate. The climate of this zone is typically semi-arid, characterized with wide range of temperature between summer and winter. The average rainfall of the locality is around 650 mm of which 85% is contributed by SW monsoon during July to August.

Prototype details: The crop establishment constraints in rapeseed-mustard were identified as; high seed rate, seed breakage, less seed germination, uneven plant population, uneven seeding depth, limited soil moisture and simultaneous fertilizer drilling. Farmers generally use ordinary wheat seed drill which is primarily developed for wheat sowing. The prototype of Mustard Planter was customized and developed by the scientists from ICAR-DRMR, Bharatpur in due collaboration with scientist from CIMMYT and BISA, India and manufactured from National Agro Industries, Ludhiana. The prototype consists of six specially designed sloping (45°) tynes for deep sowing at 45 cm row to row and 15–20 cm plant to plant spacing with seeding at 1–1.5-inch uniform depth. The seed metering mechanism is fluted feed type in which adjustable fluted rollers were made of fiber plastic to reduce the breakage of delicate mustard seeds. The feed roller mounted on a shaft and carries grooves of size equal to mustard seeds, and pick and drop the seeds in the seed tube. Seed rate can be controlled by shifting the fluted rollers sideways and exposing the length of the grooves. Depth control wheel were also provided for uniform seeding depth without any support from the hydraulic lever. A separate box for simultaneous fertilizer drilling was also attached to the main unit. Also, a multi crop seeding attachment provided with the main unit for the sowing of other course to small grain crops because the farmers' in rainfed areas are generally poor and cannot afford a separate seed drill for mustard only.

Field trials: Field trials were conducted to test the performance of Mustard Planter and effect on plant growth and yield at research station as well as at farmer's fields during 2016–18 in the Bharatpur region. The evaluation trials were conducted for two consecutive years at farmer's field (10 trials) and at research station. The fields were prepared with preparatory tillage operations to fine tilth under conserved soil moisture at farmers' field and with pre-sowing irrigation at research farm. After the final field preparation, seeds of Indian mustard variety RH 406 at research station and RH 749 and DRMRIJ 31 at farmer's field were sown at the rate of 4 kg/ha with Mustard Planter as well as wheat seed drill for comparison. Uniform fertilizer rate of 80:60:40:40:25:1 N:P:K:S:ZnSo4:B were applied both at research and farmers' trials. Half quantity of N was applied as basal dose and remaining half at first irrigation. First irrigation at 35 DAS and second at 65 DAS were given with top dressing of remaining half N. The crop was harvested when 80% siliquae turn yellowish brown to prevent siliquae shattering.

Observations: The dry matter accumulation was recorded by taking 5 plants from each plot and dried

in the hot air oven at 70°C for 48 h to get constant weight. Ten randomly tagged plants were used for measuring plant height, number of branches (primary and secondary) and plant girth. Leaf area (LICOR 3100 leaf area meter) and relative water content were measured at 60 days after sowing in a clear sky day between 11.00 am to 12.00 pm from five randomly selected plants from each treatment. The fifth well exposed leaf of normal physiological status was used for sampling and recorded the fresh and dry weight, and calculated the RWC (Barrs and Weatherley 1962).

$$\text{RWC (\%)} = (\text{Fw} - \text{Dw}) / (\text{Tw} - \text{Dw}) \times 100$$

where, Fw, Fresh weight of leaf; Dw, Dry weight of leaf; Tw, Turgid weight of leaf.

The chlorophyll content was measured using SPAD chlorophyll meter reading (SCMR) at 85 DAS. SCMR data were recorded on top, middle and bottom leaves from five randomly selected plants. Ten siliquae of each five plant were used for measuring siliquae weight and assimilate supply pattern. The seed yield of net plot after cleaning and proper drying was recorded in gram and converted into kilogram per hectare. Seeds from 5 representative plants from each plot were used for weighing and calculated the test weight. Soil profile moisture content was determined by gravimetric method. Plot-wise soil samples were drawn at depth intervals of 0-30 cm and 30-60 cm soil layers at 30, 60, 90 DAS and at harvest at the research station, and from 0-15 and 15-30 cm at 85 DAS at farmer's trial using a screw auger and weighed for fresh weight. Thereafter, soil samples were oven dried at 70°C for 48 h to obtain dry weight. Soil moisture content of soil samples was worked out as:

$$\text{Soil moisture content (\%)} = (W_1 - W_2) / (W_2 - W_3) \times 100$$

where, W_1 , Fresh weight of soil (g); W_2 , Dry weight of soil (g); W_3 , Can weight (g).

The market price of inputs at the time of purchase were taken into consideration to work out the cost of cultivation and gross income (₹/ha). The net income (₹/ha) was calculated by deducting the cost of cultivation (₹/ha) from gross income and benefit cost ratio was worked out as follows:

$$\text{B:C ratio} = \text{Net income (₹/ha)} / \text{cost of cultivation (₹/ha)}$$

The data obtained were subjected to statistical analysis using Microsoft Excel. Analysis of variance (ANOVA) was done as per the procedure outlined by Gomez and Gomez (1984). The significant differences between treatments were compared with the least significance (LSD) at 5% level of probability ($P=0.05$).

RESULTS AND DISCUSSION

Research station trials: The performance trials of Mustard Planter were conducted at research station and compared with ordinary wheat seed drill. Results showed no significant variation in plant height and SCMR due to

Table 1 Growth, yield and physiological parameters and economics of Mustard Planter and wheat seed drill sown Indian mustard.

Seeding machines	Plant height (cm)	Primary branches/plant	Secondary branches/plant	Basal node girth (cm)	SCMR (90 DAS)	LAI (60 DAS)	% RWC (90 DAS)	Seed yield (kg/ha)	Harvest index (%)	Test weight (g)	Net income (₹/ha)	B : C ratio
Wheat seed drill	217	12.9	38.6	11	46.7	4.7	81.0	2477	28.2	5.9	58565	2.5
Mustard planter	231	14.9	45.3	12.3	50.4	5.2	88.4	2699	31.5	6.7	66330	2.9
SEm±	6.8	0.4	1.3	0.3	1.4	0.2	2.1	66	0.9	0.3	1943	0.1
CD (P=0.05)	NS	1.3	4.4	1.1	NS	0.5	6.5	206	2.9	0.6	6337	0.5

Cost of cultivation of Mustard Planter-₹21300/ha; Cost of cultivation of wheat seed drill-₹23466/ha

seeding machines, however, branches per plant, girth of basal node, LAI, RWC, seed yield, harvest index and benefit margin increased markedly with Mustard Planter (Table 1). Sowing with Mustard Planter recorded higher plant height (+6.5%), primary branches (+15.5%), secondary branches (+17.4%), basal node girth (+11.8%), SCMR (+7.9%), LAI (+10.6%) and RWC (+9.1%) over wheat seed drill. Mustard Planter sown crop recorded significantly higher seed yield (+9%), harvest index (+11.7%), test weight (+13.6%) and B:C ratio (+16%) over wheat seed drill sown crop.

Results revealed that moisture content was always higher in the plots sown with Mustard Planter in all the sampling compared to plots sown with wheat seed drill at research field (Fig 1). Mustard Planter sown plots retained moisture content higher by +6.4-10.8% at 0-30 cm and +4.8-15.8% at 30-60 cm soil depth over wheat seed drill sown plots during the crop season. The moisture content was higher at deeper soil layer (30-60 cm) compared to upper layer (0-30 cm).

Farmer's field trials: Trials were conducted at 10 farmer's field using two varieties RH 749 and DRMRIJ 31 during the period and observations were recorded. The crops sown with wheat seed drill recorded just double the average plant population (35 plants/m²) compared to Mustard Planter (16 plants/m²) at harvest (Table 2).

Sowing with Mustard Planter recorded plant height (188 and 210 cm), primary branches (11.4 and 15 per plant), secondary branches (19.8 and 29.4 per plant) and girth of basal nodes (7.0 and 7.4 cm) at 80 DAS and at harvest, respectively. Mustard Planter sown crop recorded 51% less plant population, 5.5% higher plant height, 5% higher primary branches/plant, 27.8% higher secondary branches/plant and 19.4 higher basal node girth compared to wheat seed drill crop at farmer's field (Table 2).

Crop sown with Mustard Planter and wheat seed drill showed deferential dry matter assimilation in source and sink parts (Fig 2). Plant dry matter accumulation (without siliquae) at harvest was +25% in the Mustard Planter sown crop (45 g/plant) compared to wheat seed drill crop (36 g/plant), whereas, siliquae weight was +78.8% higher in Mustard Planter sown crop (20 g/plant) compared to wheat seed drill sown crop (11.2 g/plant). The crop sown with Mustard Planter recorded higher leaf chlorophyll content at 85 DAS (49.9) in all the trials compared to sowing with wheat seed drill (41.4) (Fig 2). Mustard Planter sown crop recorded more greenness and increased SCMR from +7.7 to +38.9% compared to wheat seed drill sown crop. The crop sown at farmer's field with Mustard Planter recorded average seed yield of 30.5 q/ha which was 5.6 q/ha higher over wheat seed drill sown crop (24.9 q/ha) (Fig 2). Sowing

with Mustard Planter increased seed yield by +22.3% compared to wheat seed drill at farmer's field. Likewise, Mustard Planter sown crop recorded ₹81725/ha as net return which was higher by ₹19147/ha over wheat seed drill sown crop (₹62578/ha). The net returns were increased by +19.2% with Mustard Planter compared to wheat seed drill (Fig. 2). The soil moisture was measured at 85 DAS at two depths (0-15 and 15-30 cm) at farmer's field and found that plots sown with Mustard Planter recorded higher soil moisture content at both the soil layers (Fig. 2). At 0-15 cm soil depth,

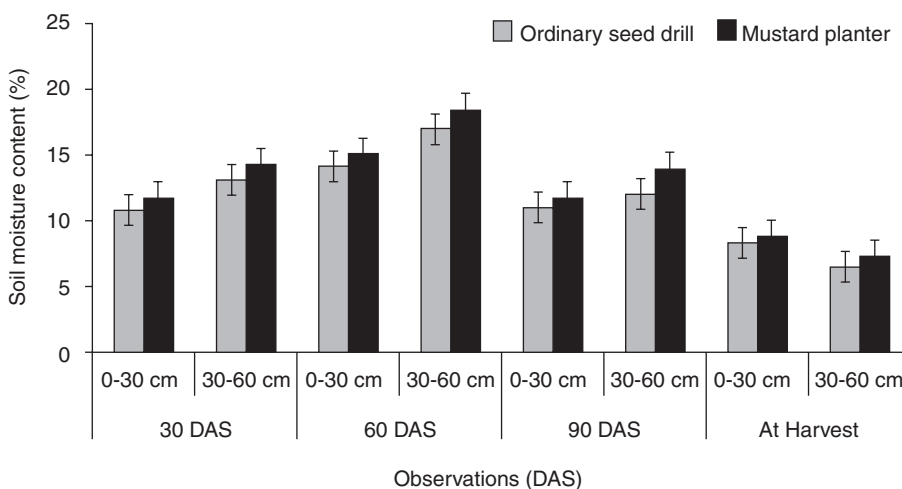


Fig 1 Soil moisture content influenced with Mustard Planter and wheat seed drill at research field.

Table 2 Growth parameters of Indian mustard influenced with Mustard Planter and wheat seed drill at farmer’s field

	Stage of observation									
	80 DAS					At harvest				
	Plant/ m ²	Plant height (cm)	Primary branches	Secondary branches	Basal node girth	Plant/ m ²	Plant height (cm)	Primary branches	Secondary branches	Basal node girth
Farmers practice	35	155	8.4	17	5.9	31	199	10	23	6.2
Mustard Planter	16	188	11.4	19.8	7.0	15	210	15	29.4	7.4

moisture retained +126% higher with Mustard Planter (9.5% moisture) compared to wheat seed drill sown crop (4.2% moisture). Mustard Planter sown plots also recorded higher soil moisture at 15-30 cm depth (10.7% moisture) which was +102% higher over wheat seed drill (5.3% moisture).

The competitive ability of mustard plants greatly depends upon the plants per unit area which ultimately affect the primary and secondary branches, siliquae setting pattern, number of siliquae/plant and other yield attributes (Rajput 2012, Shekhawat *et al.* 2012, Kamal *et al.* 2015, Harikesh *et al.* 2017,). The results were discussed with the background information on crop geometry and its effects on Indian mustard due to paucity of published work on mechanical sowing of Indian mustard. Mustard Planter recorded better crop growth and yield parameters over wheat seed drill at both research station as well as farmer’s field trials. The crop sown with Mustard Planter resulted into better growth attributes might be due to seeding in the moist zone at optimum geometry which resulted into better seed germination and early seedling establishment than sowing with wheat seed drill. A good start of the crop sown with Mustard Planter might have accelerated water and nutrient uptake and translocation thus, accumulated more dry matter with more basal node’s girth and developed

more number of primary and secondary branches and leaf area. Literature showed that mustard crop geometry of 45 cm row to row and 15 cm plant to plant resulted into more number of branches/plant (Mirza *et al.* 2008; Paraye *et al.* 2009, Pandey *et al.* 2015), crop growth rate (CGR) and above ground dry biomass accumulation (Tyagi and Upadhyay 2016). Mustard Planter sown crop retained more chlorophyll and leaf relative water content might be due more water allocation to the plants at optimum population, and favourable land configuration facilitated more light interception, less transpiration and less evaporation due to soil mulch (Singh *et al.* 2015). Crop sown with Mustard Planter recorded more diversion of photosynthates towards sink part (siliquae) than in sources (plant leaves and stem) due to better crop establishment and plant architecture at optimum plant population by maintaining proper row and plant geometry which rendered into more space for sink development and better yield of the crop (Alam 2004). Increase in seed yield with Mustard Planter valorized due to better crop establishment, growth environment, growth and yield attributes and assimilates diversion to the sink. Mustard Planter sown plots retained more soil moisture till harvest of the crop might be due to optimum plant population (@ 2.5-3.0 kg seed rate/ha) compared to dense plant

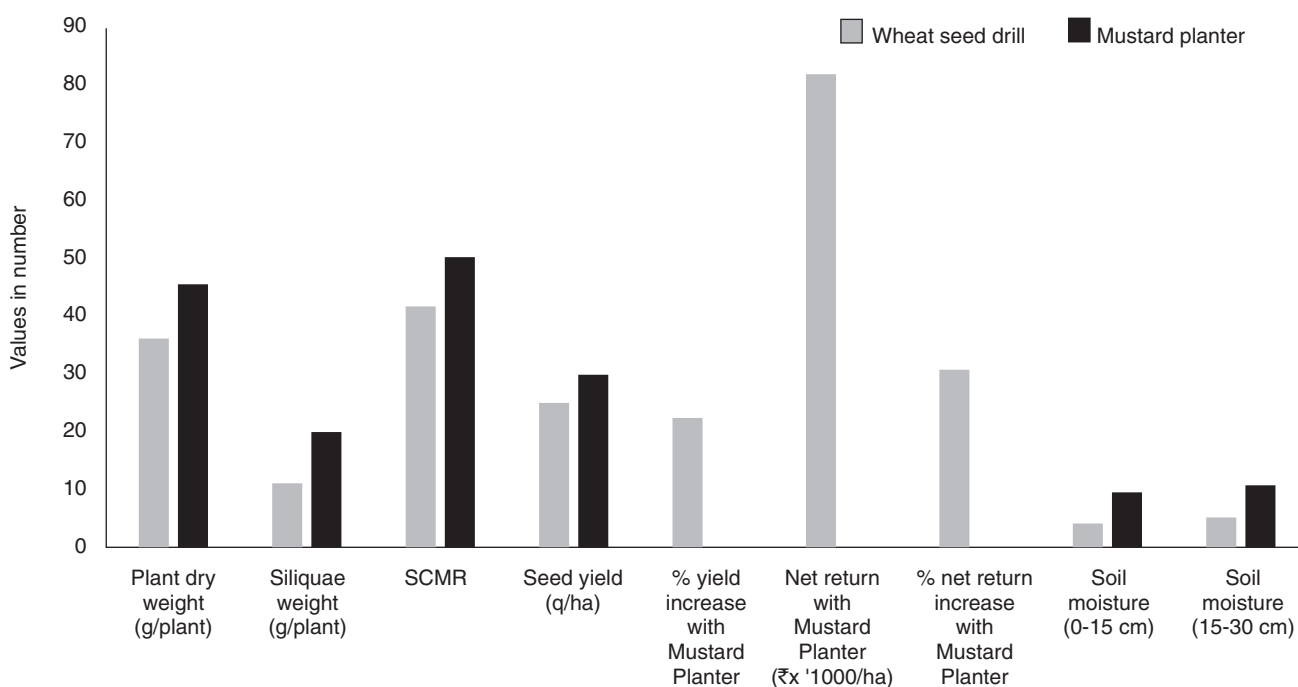


Fig 2 Plant growth, yield, economics and soil moisture influenced with Mustard Planter and farmer’s practice.

population (@ 5-6 kg seed rate/ha) in case of wheat seed drill sown plots which exhausted the soil moisture at faster rate. The effects are more pronounced under the present study due to rainfed conditions where water is the major limiting factor. If, resources are limited by environmental conditions, competition will be more severe at the higher plant density. At optimum plant population, the resource will be optimal to each individual plant (Bucci *et al.* 2008, Zou *et al.* 2008, Campo *et al.* 2014) and, therefore, growth rates and probability of survival will be higher contrary to higher plant density that decrease seed yield and total biomass (Lemma *et al.* 2009). Mustard Planter sown crop accrued more economic benefits over wheat seed drill might be due to higher seed yield. Also, the cost of cultivation with Mustard planter was less due to less seed requirement per unit area compared to wheat seed drill and thus, recorded more benefit:cost ratio. Also, there was less seed breakage in the customized Mustard Planter which was an added advantage over wheat seed drill.

Mustard Planter was found an appropriate and efficient seeding machine in terms of crop growth and yield attributes, plant water balance, soil moisture retention and seed yield compared to traditional wheat seed drill. Also, the Mustard Planter realized more profit margins over wheat seed drill and therefore, there is need to spread the technology for Brassica production system to enhance the farmers' profitability.

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