



Effect of Sowing Dates, Tillage and Establishment Methods on Growth and Yield of Mustard

**P. Sneha Reddy ^{a*}, G. Satyanarayana Reddy ^a, K. B. Suneetha Devi ^a
and A. Krishna Chaitanya ^b**

^a Department of Agronomy, Agricultural College, Polasa, Jagtial, Professor Jayashankar Telangana State Agricultural University, Telangana, India.

^b Department of Soil Science & Agricultural Chemistry, Agricultural College, Polasa, Jagtial Professor Jayashankar Telangana State Agricultural University, Telangana, India.

Authors' contributions

This work was carried out in collaboration of all authors. Author PSR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author GSR mentored and monitored the work. Authors KBSD and AKC managed the analyses of the study. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2021/v11i11130531

Editor(s):

(1) Dr. Daniele De Wrachien, State University of Milan, Italy.

Reviewers:

(1) Khalid Zemam Amer, Mustansiriyah University, Iraq.

(2) Rasha Nagy Arafa, Egypt.

(3) Viktor Sheichenko, Poltava State Agrarian University, Ukraine.

Complete Peer review History: <https://www.sdiarticle4.com/review-history/76615>

Original Research Article

Received 07 September 2021

Accepted 15 November 2021

Published 18 November 2021

ABSTRACT

This experiment was conducted at College Farm, Agricultural College, Polasa, Jagtial in *Rabi*, 2019-20. The experiment was laid out in strip-plot design with T₁-Zero tillage with direct sowing, T₂-Zero tillage with transplanting, T₃-Conventional tillage with direct sowing and T₄-Conventional tillage with transplanting in 4 horizontal strips and D₁-15 November, D₂-25 November and D₃-5 December sowing dates in 3 vertical strips. Nursery was prepared 15 days earlier to sowing date for transplanting. Direct sowing and transplanting was carried out on same date. Among tillage practices with establishment methods, significantly the highest performance of growth parameters was obtained with T₄ and lowest response under T₁. Significantly higher values of growth parameters were recorded under early sowing date (15 November) followed by 25 November and lowest was registered on 5 December. The number of siliqua plant⁻¹, seeds siliqua⁻¹ was significantly higher under T₄ which resulted in higher seed yield (754.38 kg ha⁻¹), stover yield

*Corresponding author: E-mail: paipatisnehareddy144@gmail.com;

(1815.40 kg ha⁻¹) and was comparable with T₃. Higher number of siliqua per plant⁻¹ and number of seeds per siliqua⁻¹ resulting in higher seed yield (944.55 kg ha⁻¹) and stover yield (1943.12 kg ha⁻¹) were recorded on 15 November followed by 25 November and lowest was registered on 5 December.

Keywords: Conventional tillage; direct sowing; seed yield, sowing dates; straw yield; Transplanting; zero tillage.

1. INTRODUCTION

Oilseeds are the second largest agricultural commodity after cereals play a vital role in Indian economy, accounting for 5% of gross national product and 10% of the value of agricultural product. India is the fourth largest oilseed economy in the world after the U.S., China and Brazil and it is the second largest importer after China.

Mustard is the best alternative oilseed crop for crop diversification and doubling the farm income with minimal inputs and good care.

Mustard is cultivated mostly under temperate climates. Also, it is grown in certain tropical and subtropical regions as a cool weather crop. Rapeseed-mustard is considered as sensitive to weather as evidenced from the variable response to different dates of sowing [1]. Time of sowing is very important for mustard production [2] Optimum sowing time plays an important role to fully exploit the genetic potential of a variety as it provides optimum growth conditions such as temperature, light, humidity and rainfall [3]. Any crop has an advantage of its performance when growth period is synchronized with optimum environmental conditions. The yield of mustard in India is low as the crop is grown under rainfed condition. There is a scope in increasing mustard productivity despite of late sowing with new production technologies.

The crop is usually grown during November to January. Since rainfall during this period is inadequate and uncertain, conservation tillage (zero-tillage + residue mulching + crop diversification) is a useful practice in rainfed areas to control soil erosion and weed growth as well as to preserve soil moisture and plant nutrients in the soil profile [4]. Transplanted crop have the exact plant population with mathematical precision and it also has time benefit even after delay in harvest of the *kharif* crops. Through transplanting, the full potentiality of individual plants can be realized and achieve more yield than drilling of seeds [5]. The main

objective of the research is to increase mustard area and productivity with new production technologies.

2. MATERIALS AND METHODS

This experiment was conducted during *Rabi*, 2019-20 at College farm, Agricultural College, Polasa, Jagtial, PJTSAU located at 78°57'0.036" E longitude and 18°50'39.2964" N latitude and at an altitude of 243.4 m above mean sea level. The mean weekly meteorological observations were recorded at observatory, RARS, Polasa. The highest and lowest temperatures recorded during the crop growth period are 32.7°C and 15.5°C respectively. The mean relative humidity fluctuated between 51.3 and 80. The bright sunshine hours varied from 8.5 in November to 4.7 in March. The total rainfall of 34.5 mm received in 4 rainy days during crop growth period. The soil at the experimental site was sandy loam in texture with a fraction of sand-56.4%, silt-27.1%, clay-16.5% and pH of 7.9, EC of 0.24 dSm⁻¹, bulk density of 1.44, organic carbon of 0.5 g/kg, available N of 177.6 kg ha⁻¹, P₂O₅ of 20.3 kg ha⁻¹, K₂O of 502 kg ha⁻¹.

The experiment was designed in strip-plot with four tillage and establishment methods viz. T₁-zero tillage with direct sowing, T₂-zero tillage with transplanting, T₃-conventional tillage with direct sowing and T₄-conventional tillage with transplanting in horizontal strips and three dates of sowing viz. D₁-15 November, D₂-25 November and D₃-5 December in vertical strips and replicated thrice. The crop was sown in 9.45 m² net plot area with a spacing of 45 x 15 cm.

The fertilizers were applied at the rate of 120:60:60 kg ha⁻¹ N, P and K respectively. A full dose of P, half of N and K was applied as basal dose at the time of last plough through urea, single super phosphate and muriate of potash. Ploughing was done with MB plough to a depth of 15-30 cm and levelled with a leveler in conventional tillage plots whereas soil was left undisturbed after the harvest of previous crop in zero tillage plots. Remaining half doses of N and

K were applied at 35 DAS as topdressing according to sowing dates. Intercultural operations such as weeding and thinning were done as and when necessary. For determining growth parameters like plant height, leaf area, number of primary branches per plant, number of secondary branches per plant, SPAD chlorophyll meter readings were recorded by randomly selecting five plants from net plot. Yield and yield attributing characters were recorded using standard procedures. Final yield was expressed as kg ha^{-1} .

For transplanting, seedlings were raised in a nursery bed which was prepared 15 days earlier to the sowing date and transplanting of 10-15 days old seedlings were done in the field on that respective planting date. The plants of 2-3 leaves were ready for transplanting and translated in the pits at a depth of 5-10 cm. After transplanting, light irrigation was given for better establishment of seedlings. The crop was affected by aphids during maturity period and recommended control measures were carried out. The crop was harvested when 80% siliqua were turned to straw yellow colour.

3. RESULTS AND DISCUSSION

3.1 Crop Growth Parameters

Data regarding various growth parameters as influenced by various treatments are mentioned in Tables 1 and 2.

3.1.1 Initial and final plant stand m^{-2} (percent)

Plant population per unit area provides basis for yield comparisons under different treatments. The data pertaining to initial and final plant population m^{-2} of mustard as influenced by sowing dates, tillage and establishment methods were presented in Table 1.

The critical evaluation of experimental data after statistical analysis revealed that there was no significant difference in initial plant population m^{-2} but had significant difference in final plant population m^{-2} among tillage with establishment methods and among the dates of sowing. However, the highest percentage of initial and final plant population of (96.83, 93.39) was observed in T_4 -conventional tillage with transplanting followed by T_3 -conventional tillage with direct sowing (94.97, 91.27) and T_2 -zero tillage with transplanting (92.06, 89.47) where as the lowest percent of initial and final plant

population (90.48, 86.24) was observed in T_1 -zero tillage with direct sowing.

There was no significant difference in initial plant population m^{-2} but significant difference in final plant population m^{-2} was observed among dates of sowing. However, the percent of initial and final plant population was highest under crop sown on 15 November (95.84, 93.65) followed by 25 November (94.05, 90.48) and the lowest percent was seen in 5 December (90.87, 86.11).

3.1.2 Plant height (cm)

The data in respect of mean plant height revealed that plant height increased as plant advanced in age and reached to maximum at harvest. Significantly, the tallest plants were observed in T_4 -conventional with transplanting (13.98 cm) and were at par with T_3 -conventional tillage with direct sowing (13.49) followed by T_2 -zero tillage with transplanting (13.00). The lowest plant height was observed in T_1 -zero tillage with direct sowing (12.44) at 30 DAS. At 60 DAS, significantly taller plants were recorded under T_4 -conventional tillage with transplanting (125.09), which was on par with T_3 -conventional tillage with direct sowing (117.49) and T_2 -zero tillage with transplanting (110.37) whereas the lowest plant height was recorded under T_1 -zero tillage with direct sowing (96.82). It was observed that significantly the taller plants were obtained in T_4 -conventional with transplanting (140.37 cm) and was at par with T_3 -conventional tillage with direct sowing (135.79). The lowest plant height was obtained in T_1 -zero tillage with direct sowing (128.37), which was on par with T_2 -zero tillage with transplanting (122.09) at harvest. The plant height of mustard increased progressively with increase in intensity of tillage due to congenial condition for proliferation of roots to deeper layers for moisture and nutrient uptake under conventional tillage. Similar results were reported by (6), (15), (7) and (3).

At 30 DAS and at harvest, significantly taller plants were obtained on 15 November (13.89, 148.09) followed by 25 November (13.05, 137.97) and lowest plant height was recorded on 5 December (12.74, 108.91). At 60 DAS, crop sown on 15 November (129.43) has recorded taller plants which were on par with 25 November (113.07) and lowest plant height was recorded on 5 December (94.83). The highest plant height was recorded on 15 November. This might be due to mustard sown on early date was available to more photoperiod than delayed

sown crop. Similar results were reported by (20).

Interaction of tillage with establishment methods and dates of sowing for plant height was non-significant at all the stages.

3.1.3 Dry matter accumulation (kg ha⁻¹)

Significant differences were observed for dry matter accumulation at 30, 60 DAS and at harvest in both main treatments and sub treatments. At 30 DAS, highest dry matter accumulation was recorded in T₄-conventional tillage with transplanting (245.47) and it was significantly superior over T₃-conventional tillage with direct sowing (176.87) and T₂-zero tillage with transplanting (115.50). The lowest dry matter (86.10) was recorded in T₁-zero tillage with direct sowing. Highest dry matter was observed in T₄-conventional tillage with transplanting (1782.67) and was at par with T₃-conventional tillage with direct sowing (1694.00). The lowest dry matter was recorded in T₁-zero tillage with direct sowing (1040.67) and was at par with T₂-zero tillage with transplanting (1117.67) at 60 DAS. At harvest, similar trend was observed in dry matter accumulation among tillage practices with establishment methods. Significantly highest dry matter accumulation was recorded in T₄-conventional tillage with transplanting (2940.00) which was on par with T₃-conventional tillage with direct sowing (2599.33) and T₂-zero tillage with transplanting (2396.33) and lowest dry matter was recorded in T₁-zero tillage with direct sowing (2044.00).

The plant dry matter accumulation of mustard increased progressively with increase in intensity of tillage which provided better soil condition for proliferation of roots to deeper layers for uptake of moisture and nutrients which resulted in accumulation of dry matter with increase in plant height, leaf area, number of branches. Similar results were reported by [6,2,7].

At all the stages of observation *i.e.*, 30 DAS, 60 DAS and harvest, dates of sowing has followed the same trend. Significantly highest dry matter accumulation has been recorded on first sowing date *i.e.*, 15 November (190.40, 1905.75, 3491.25) which was superior over 25 November (158.55, 1389.50, 2812.25 kg ha⁻¹) and the lowest plant dry matter was recorded on 5 December (119, 931, 1181.25 kg ha⁻¹) at 30, 60 DAS and at harvest respectively. Mustard sown on early date has an advantage of favourable

weather conditions which increased photosynthetic activity and translocation of food material from source to sink which resulted in higher plant dry matter accumulation. Similar results were also observed by the [8,9,5].

Interaction of tillage with establishment methods and dates of sowing for dry matter accumulation was non-significant at all the stages.

3.2 Yield Attributes and Yield

3.2.1 Number of siliqua plant⁻¹

A significant difference in number of siliqua plant⁻¹ was observed due to both tillage practices with establishment methods and dates of sowing were presented in Table 3.

Significantly higher number of siliqua plant⁻¹ was noticed in T₄-conventional tillage with transplanting (283.70) which is at par with T₃-conventional tillage with direct sowing (275.07) and T₂-zero tillage with transplanting (260.62). However, T₁-zero tillage with direct sowing has recorded lowest number of siliqua plant⁻¹ (240.73). This might be due to better performance of crop under conventional tillage treatments compared to zero tillage treatments.

Number of siliqua plant⁻¹ has decreased with delay in sowing date. Mustard sown on 15 November (344.13) has recorded significantly higher number of siliqua plant⁻¹ followed by 25 November (297.59) and lowest number of siliqua plant⁻¹ on 5 December (153.37). The delay in sowing of mustard caused crop growth stages to experience higher temperatures hastening the maturity resulting in reduced assimilates production and allocation to sink. Similar results were obtained by [8,10].

It was found that there was no significant interaction among tillage, establishment methods and sowing dates for the number of siliqua plant⁻¹.

3.2.2 Number of seeds siliqua⁻¹

There was a significant difference in number of seeds siliqua⁻¹ in both main treatments and sub treatments.

Mustard sown on 15 November (13) has recorded significantly higher number of seeds siliqua⁻¹ followed by 25 November (12.02) and lowest number of seed siliqua⁻¹ was recorded

under 5 December (10.68). Synchronization of siliqua filling period with high temperatures has shortened siliqua filling period which might have affected the process of seed formation in crop resulted in less number of seeds per siliqua under late sown conditions. Similar results were reported by [12] and [13].

Table 1. Initial and final plant stand per m² of mustard as influenced by sowing dates, tillage and establishment methods

Treatments	Initial plant stand m ⁻²		Final plant stand m ⁻²	
	Per m ²	Per cent	Per m ²	Per cent
Main treatments				
T 1 - Zero tillage + Direct sowing	19.00	90.48	18.11	86.24
T 2 - Zero tillage + Transplanting	19.33	92.06	18.78	89.42
T 3 - Conventional tillage + Direct sowing	19.94	94.97	19.17	91.27
T 4 - Conventional tillage + Transplanting	20.33	96.83	19.61	93.39
SEm ±	0.28	1.34	0.27	1.27
CD (P=0.05)	NS	NS	0.92	4.39
Sub treatments				
D 1 – 15 November	20.13	95.84	19.67	93.65
D 2 – 25 November	19.75	94.05	19.00	90.48
D 3 – 5 December	19.08	90.87	18.08	86.11
SEm ±	0.31	1.48	0.17	0.79
CD (P=0.05)	NS	NS	0.65	3.12
Interaction				
SEm ± (M x S)	0.47	2.23	0.39	1.85
CD (P=0.05)	NS	NS	NS	NS
SEm ± (S x M)	0.50	2.39	0.34	1.64
CD (P=0.05)	NS	NS	NS	NS

Table 2. Plant height (cm) and dry matter accumulation (kg ha⁻¹) of mustard as influenced by sowing dates, tillage and establishment methods

Treatments	Plant height (cm)			Dry matter accumulation (kg ha ⁻¹)		
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
Main treatments						
T ₁ - Zero tillage + Direct sowing	12.44	96.82	122.09	86.10	1040.67	2044.00
T ₂ - Zero tillage + Transplanting	13.00	110.37	128.37	115.50	1117.67	2396.33
T ₃ - Conventional tillage + Direct sowing	13.49	117.49	135.79	176.87	1694.00	2599.33
T ₄ - Conventional tillage + Transplanting	13.98	125.09	140.37	245.47	1782.67	2940.00
SEm ±	0.19	4.63	3.19	7.88	130.82	157.06
CD (P=0.05)	0.66	16.01	11.05	27.28	452.69	543.48
Sub treatments						
D ₁ - 15 November	13.89	129.43	148.09	190.40	1905.75	3491.25
D ₂ - 25 November	13.05	113.07	137.97	158.55	1389.50	2812.25
D ₃ - 5 December	12.74	94.83	108.91	119.00	931.00	1181.25
SEm ±	0.07	4.57	1.38	2.68	86.43	121.82
CD (P=0.05)	0.26	17.94	5.42	10.54	339.38	478.33
Interaction						
SEm ± (M x S)	0.30	7.94	5.89	11.21	179.77	260.61
CD (P=0.05)	NS	NS	NS	NS	NS	NS
SEm ± (S x M)	0.26	8.23	5.43	8.87	156.76	251.99
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Table 3. Number of siliqua plant⁻¹, Number of seeds siliqua⁻¹, seed yield (kg ha⁻¹) and stover yield (ka ha⁻¹) of mustard as influenced by sowing dates, tillage and establishment methods

Treatments	Number of siliqua plant ⁻¹	Number of seeds siliqua ⁻¹	Seed yield (kg ha ⁻¹)	Stover yield (kg ha ⁻¹)
Main treatments				
T ₁ - Zero tillage + Direct sowing	240.73	11.42	550.17	1348.38
T ₂ - Zero tillage + Transplanting	260.62	11.64	594.84	1392.59
T ₃ - Conventional tillage + Direct sowing	275.07	12.18	752.04	1753.79
T ₄ - Conventional tillage + Transplanting	283.70	12.36	754.38	1815.40
SEm ±	6.68	0.10	34.47	64.25
CD (P=0.05)	23.12	0.35	119.28	222.32
Sub treatments				
D ₁ - 15 November	344.13	13.00	944.55	1943.12
D ₂ - 25 November	297.59	12.02	796.14	1844.44
D ₃ - 5 December	153.37	10.68	247.88	945.06
SEm ±	6.43	0.07	53	84.85
CD (P=0.05)	25.26	0.29	208.12	333.15
Interaction				
SEm ± (M x S)	12.93	0.25	87.93	177.24
CD (P=0.05)	NS	NS	NS	NS
SEm ± (S x M)	13.39	0.25	100.85	194.67
CD (P=0.05)	NS	NS	NS	NS

The interaction among tillage with establishment methods and dates of sowing for number of seeds siliqua⁻¹ was found to be non-significant.

3.2.3 Seed yield (kg ha⁻¹)

The results pertaining to seed yield (kg ha⁻¹) of mustard influenced by different tillage practices with establishment methods and dates of sowing is presented in the Table 3.

The data revealed that there was significant increase in seed yield with increasing intensity of tillage operations. T₄-conventional tillage with transplanting has recorded significantly higher seed yield (754.38 kg ha⁻¹) and was at par with T₃-conventional tillage with direct sowing (752.04 kg ha⁻¹). The higher seed yield in conventional tillage might be due to the pulverization of soil which enhanced penetration of roots to deeper layer of soils facilitate greater uptake of water and nutrients from the soil enhanced yield attributes and finally the seed yield of mustard. The lowest seed yield was recorded under T₁-zero tillage with direct sowing (550.17 kg ha⁻¹) which was at par with T₂-zero tillage with transplanting (594.84 kg ha⁻¹). The reduction in seed yield of crop under zero tillage might be due to comparatively higher soil compaction, poor seed soil contact, poor growth of root and lower uptake of nutrients than conventional

tillage resulting plants with lower yield attributes. Similar results have also been reported by (4), (22), (15), (5), (16) and (12).

It was also clear from the data that delay in sowing significantly reduced the seed yield of mustard. Higher seed yield was recorded on 15 November (944.55 kg ha⁻¹) and was at par with 25 November (796.14 kg ha⁻¹) as the mustard crop prefers low temperature for growth, it might be the reason for the highest seed yield on 15 November. The lowest seed yield was obtained on 5 December (247.88 kg ha⁻¹). Delay in sowing of mustard decreased seed yield due to synchronization of siliqua filling period with high temperatures. The shortening of siliqua filling period which resulted in less number of siliqua plant⁻¹, seeds siliqua⁻¹ and test weight (g). Delayed sowing has shown maximum pest infestation due to high temperature, which created favourable condition for insect generation. Similar results were reported by [14,15].

Interaction of tillage with establishment methods and dates of sowing for 1000 seed yield was non-significant at harvest.

3.2.4 Stover yield (kg ha⁻¹)

It was evident from the data shown in Table 3 that increase in the intensity of tillage operations

increased the stover yield respectively. T₄-conventional tillage with transplanting (1815.40 kg ha⁻¹) has recorded higher stover yield and was at par with T₃-conventional tillage with direct sowing (1753.79 kg ha⁻¹). The lowest stover yield was recorded under T₁-zero tillage with direct sowing (1348.38 kg ha⁻¹) which was at par with T₂-zero tillage with transplanting (1392.59 kg ha⁻¹). The higher stover yield recorded in conventional tillage might be due to proper tillage which enhanced soil condition for vegetative growth, dry matter accumulation, photosynthetic activity and finally the stover yield. These results were in agreement with the findings of [16,7,18,11].

It was also clear from the data that delay in sowing reduced the stalk yield significantly. Higher stalk yield was recorded on 15 November (1943.12 kg ha⁻¹) which was at par with 25 November (1844.44 kg ha⁻¹) and both were superior to 5 December (945.06 kg ha⁻¹) which recorded the lowest stalk yield. Similar results were reported by [19,20].

4. CONCLUSION

Performance of mustard under conventional tillage with transplanting and direct sowing was more consistent than zero tillage with transplanting and direct sowing with higher values for growth parameters, yield attributes and yield. Hence mustard growing on zero tillage requires more care at the time of establishment compared to conventional tillage.

Mustard sown on 15 November has recorded significantly higher seed yield, stover yield with higher growth, yield attributes and yield but statistically comparable with 25 November. Late sowings has showed drastic deviation in yield from average yield of mustard. Mustard cultivation with conventional tillage on early sowing dates is more remunerative.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:

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