Annals of Plant and Soil Research 17(4): 413-417 (2015)

EFFECT OF SOWING DATES AND VARIETIES ON TOTAL DRY MATTER AND ITS PARTITIONING IN DIFFERENT PLANT PARTS AND YIELD OF INDIAN MUSTARD

NANDLAL PATEL, P.K. TYAGI AND K.C. SHUKLA

Department of Agronomy, JNKVV, College of Agriculture Tikamgarh-472 001 (Madhya Pradesh)
Received: December- 2014; Revised accepted: September-2015

ABSTRACT

A field experiment was conducted to study the effect of sowing dates and varieties on yield attributes, yield and oil content of Indian mustard (Brassica juncea L.) under irrigated conditions during rabi 2012-13 at College of Agriculture, Tikamgarh (Madhya Pradesh). The experiment was laid out in split-plot design with three replications consisted three sowing dates (October 20, November 4 and November 19) and three varieties (Pusa Agrani, Pusa Bold and Varuna) as main plot and sub-plot treatments. October 20 sown crop resulted into significantly higher total plant biomass and its partitioning into different parts (leaves, stem and siliquae) at all growth stages, yield attributes (siliquae plant^{-1}, 1000-seeds weight), yields (seed and stover), harvest index and oil content as compared to November 4 and November 19 sown crops. Consecutive 15 days delay in sowing from October 20 to November 4 and November 19 caused a loss in seed yield by 20.5 and 39.1%., respectively. Among varieties, Pusa Bold led to record higher total biomass and its partitioning at all growth stages and resulted into higher yield attributes, yield and harvest index followed by cvs. Varuna and Pusa Agrani. Pusa Bold exhibited 29.8 and 8.24% higher seed yield over cvs. Pusa Agrani and Varuna, respectively. However, Varuna exhibited significantly higher oil content (42.0 %) followed by cvs. Pusa Bold (40.0 %) and Pusa Agrani (38.7 %).

Key words: Dry matter partitioning, Indian mustard, oil content, sowing dates, varieties

INTRODUCTION

Rapeseed-mustard is the second most important edible oilseed in India after groundnut sharing 27.8% in the India's oilseed economy. Madhya Pradesh, occupying 0.75 million hectare area with 0.86 million tonnes production accounting 11 % and 10 % of the national rapeseed and mustard area and production, respectively during 2009–10. The average productivity of rapeseed and mustard in the Madhya Pradesh is 1147 kg ha^{-1} (Anonymous, 2012). Production potentiality of Indian mustard in Madhya Pradesh can be fully exploited with suitable agronomic practices and varieties. Among different agronomic practices, research findings have shown that sowing date is one of the most important agronomic factor and non-monetary input which pave the way for better-use of time and play an important role to fully exploit the genetic potentiality of a variety as it provides optimum growth conditions such as temperature, light, humidity and rainfall. Since the temperature and solar radiation play an important role in partitioning of biomass between various organs of plant which is related to, and often governed by phenological phase of the plant and the way in which a crop develops can affect the yield and this therefore an aspect with which agronomists are much concerned. Sowing at proper time allows sufficient growth and development of a crop to obtain a satisfactory yield and different sowing dates provide variable environmental conditions within the same location for growth and development of crop and yield stability. As sowing time is one of the most important factors affecting crop yield and other agronomic traits like dry matter production, oil content, the optimization of sowing time for mustard is essential. Sowing either too early or too late has been reported to be unfavourable (Uzun *et al*., 2009). Islam and Choudhary (2002) also mentioned that mustard plants under later sowings more rapidly fulfill the low temperature requirement to initiate earlier inflorescence and flowering. But early inflorescence restricts leaf production resulting in small plant, fewer pods bearing branches and finally low dry matter yield. As the level of dry matter in plants decide the yield potential and seed yields from late sown crops are greatly affected.

It is also a fact that specified genotypes does not exhibit the same phenotypic characteristics in all environmental conditions. Improved cultivar is an important tool, which have geared production of mustard in many countries of the world. In addition to many other factors responsible for achieving higher yields, cultivars with higher yield potential and a wide range of adaptability to adaphic and climatic conditions is essential for increasing yield per unit area, ultimately boosting up total production. Panda *et al.* (2004) has also reported that the yield potential of different mustard varieties may differ under different

**Corresponding author's email: pktyagi197071@yahoo.com*

agro-climatic conditions because of their inherent capacity. The mustard genotypes differ in their yielding ability, this calls for a need to generate more information on the response of mustard genotypes to the dates of sowing for greater yields in a given agro-climatic conditions. The present study was therefore, undertaken to determine the effects of sowing dates and varieties on pattern of total biomass accumulation, its partitioning into different parts and yield of Indian mustard.

MATERIAL AND METHODS

The field experiment was conducted at Research Farm, J.N.K.V.V., College of Agriculture, Tikamgarh (24° 43' N latitude and 78° 49' E longitude at an altitude of 358m above mean sea level), Madhya Pradesh during *rabi* 2012-13. The experiment was laid out in split-plot design with three replications. The main plot treatments consisted of three sowing dates (October 20, November 4 and November 19) and the sub-plot treatments consisted of three varieties (Pusa Agrani, Pusa Bold and Varuna). The soil of experimental field was clay to clay loam with pH 6.9, low in available nitrogen (266 kgha^{-1}), rich in available P_2O_5 (25.9 kg ha^{-1}), medium in available K_2O (255 kg ha^{-1}) and organic carbon (5.0 g kg^{-1}). The recommended doses of nitrogen (80 kg N ha^{-1}), phosphorus (40 kg P_2O_5 ha^{-1}) and potassium (20 kg k_2O ha^{-1}) along with sulphur (20 kg S ha^{-1}) were applied. The mustard crop was sown in lines 30 cm apart drawn by *kudali* using a seed rate of 5 kg ha^{-1}. All other agronomic and plant protection measures were applied as per recommendations. Five plants from each plot were uprooted at fifth true leaf exposed, first flower opened, lowest pod more than 2 cm long, most seeds green and fully ripened seeds (maturity) avoiding border effects. The plants were divided into different parts *viz*., leaves, stem and siliquae (if present). The samples were then allowed to sundry for 2-3 days. Thereafter, the samples were oven dried at 60 °C for 72 hours and weighed by electronic balance. The biomass partitioning among different parts was then converted to gram per plant (g plant^{-1}). Based on biomass of different plant parts, the total biomass accumulation was obtained. Yield attributes were recorded from the five plants sample collected at the time of harvest. The crop harvested from net plot area was threshed after 4-5 days of sun drying and the seed yield of net plot was then converted into kg ha^{-1}. Before threshing of the crop harvested from net plot, the sun dried whole plant samples (biological yield) were weighed and stover yield was obtained by subtracting seed yield from biological yield. The seed oil content of all samples was determined by nuclear magnetic resonance spectrometer (NMR) (Robertson and Morrison, 1979).

RESULTS AND DISCUSSION

Total biomass and its partitioning

Irrespective of treatments, the biomass partitioning towards leaves was higher as compared to stem at fifth leaf exposed and first flower opened growth stages because the crop developed vegetatively during these stages and partitioning into siliqaue in the later growth stages when the crop entered the reproductive phase. Leaves and stem weight increased till end of reproductive phase and declined towards maturity. The decreased weight of vegetative organs after anthesis might be due to contribution of vegetative reserve to final grain yield. The allocation of biomass towards reproductive plant part/sink (siliquae) kept on increasing throughout life cycle of the plant and reached maximum at fully ripened stage (maturity).

Table 1: Effect of different treatments on total biomass and its partitioning (g plant^{-1}) at various growth stages

Treatments	Fifth true leaf exposed			First flower opened		
	Leaf	Stem	Total	Leaf	Stem	Total
Sowing dates						
20 Oct.	0.29	0.04	0.33	2.38	0.50	2.88
4 Nov.	0.21	0.03	0.24	2.04	0.42	2.47
19 Nov.	0.17	0.02	0.19	1.68	0.31	1.99
S.Em±	0.01	0.01	0.01	0.07	0.02	0.08
CD (P =0.05)	0.04	0.05	0.02	0.28	0.07	0.32
Varieties						
Pusa Agrani	0.19	0.014	0.21	1.68	0.33	2.02
Pusa Bold	0.26	0.04	0.29	2.33	0.48	2.81
Varuna	0.22	0.03	0.25	2.09	0.41	2.51
S.Em±	0.01	0.03	0.01	0.12	0.01	0.12
CD (P =0.05)	0.03	0.08	0.02	0.36	0.04	0.38

Sowing dates affected distinctly the total biomass as well as its partitioning into different plant parts. At all growth stages, the crop sown on October 20 resulted into significantly higher total plant biomass as well as its partitioning into different parts as compared to November 4 and November 19 sown crops. At fifth true leaf exposed and first flower opened growth stages, October 20 sown crop resulted into significantly higher total biomass as well as its partitioning into leaves and stem followed by November 4 and November 19 sown crops. However, biomass partitioning into stem was found non-significant between October 20 and November 4; and between November 4 and November 19 sown crops (Tables 1). Similarly, at lowest pod more than 2 cm long and most seeds green growth stages, October 20 sown crop also exhibited significantly higher total biomass and its partitioning into leaves, stem and siliquae followed by November 4 and November 19 sown crops, except biomass partitioning into stem at lowest pod more than 2 cm long growth stage where October 20 and November 4 sown crops did not differ significantly (Table 2). At fully ripened growth stage, October 20 sown crop also recorded significantly higher total biomass (46.1 g plant^{-1}) and its partitioning into stem (21.2 g plant^{-1}) and siliquae (24.9 g plant^{-1}) followed by November 4 and November 19 sown crops. However, biomass partitioning into siliquae between October 20 and November 4; and between November 4 and November 19 sown crops did not differ significantly (Table 2).

The reduction in total dry matter accumulation and its partitioning to various plant parts under delayed sowing could be attributed to unfavourable temperature and sunshine hours during crop growing season. The increased temperatures during late reproductive phase under delayed sowings hastened the maturity and therefore, the crop duration was shortened and resulted into reduced dry matter production as well as lesser partitioning into different plant parts. Similarly, the sharp rise in temperature towards maturity resulted into transpiration losses and reduced growth rate, and consequently, reduction in the dry matter accumulation. Similar results were also reported by Singh and Singh (2002) and Lallu *et al.* (2010). Correspondingly, low temperature during early and grand growth period resulted into reduced plant growth in terms of plant height, number of branches and leaf area index which ultimately affected the total dry matter production and its partitioning (Tobe *et al*., 2013).

Table 2: Effect of different treatments on total biomass and its partitioning (g plant^{-1}) at various growth stages

Treatments	**Lowest pod more than 2 cm long**				**Most seeds green**				**Fully ripened seeds**		
	Leaf	**Stem**	**Siliquae**	**Total**	**Leaf**	**Stem**	**Total**	**Leaf**	**Stem**	**Siliquae**	**Total**
Sowing dates											
20 Oct.	3.82	5.41	0.27	9.51	3.38	21.4	19.1	43.9	21.2	24.9	46.1
4 Nov.	3.36	4.97	0.23	8.56	2.90	19.9	17.7	40.4	19.8	22.3	42.1
19 Nov.	2.71	4.58	0.18	7.47	2.17	18.4	16.0	36.5	18.3	19.5	37.8
S.Em±	0.04	0.15	0.01	0.16	0.03	0.2	0.4	0.4	0.3	0.8	0.7
CD (P =0.05)	0.16	0.62	0.02	0.64	0.13	0.6	1.3	1.6	1.2	3.1	2.5
Varieties											
Pusa Agrani	2.99	4.51	0.27	7.70	2.28	17.8	16.9	36.9	18.0	21.0	39.1
Pusa Bold	3.58	5.46	0.23	9.30	3.39	21.2	18.3	42.9	21.9	23.5	45.4
Varuna	3.32	5.00	0.18	8.54	2.79	20.6	17.6	41.0	19.6	22.8	41.6
S.Em±	0.05	0.21	0.01	0.21	0.07	0.4	0.3	0.4	1.0	1.4	0.7
CD (P =0.05)	0.16	0.65	0.04	0.65	0.22	1.2	1.0	1.6	NS	NS	2.5

In general, *cv*. Pusa Bold led to record higher total biomass and it's partitioning into different plant parts *viz*., leaves, stem and siliquae followed by *cvs*. Varuna and Pusa Agrani at all growth stages (Tables 1 and 2). At fifth leaf exposed growth stage, Pusa Bold produced significantly higher total biomass as well as its partitioning into leaves and stem followed by *cvs*. Varuna and Pusa Agrani. However, biomass partitioning into stem between *cvs*. Pusa Bold and Varuna did not differ significantly. Similar trend was also observed at first flower opened growth stage except total biomass and its partitioning into leaves between *cvs*. Pusa Bold and Varuna did not differ significantly. At lowest pod more than 2 cm long and most seeds green growth stages, *cv*. Pusa Bold produced significantly higher total biomass and its partitioning into leaves, stem and siliquae followed by *cvs*. Varuna and Pusa Agrani. However, biomass partitioning into stem between *cvs*. Pusa Bold and Varuna was found non-significant. Similarly, biomass partitioning into siliquae between *cvs*. Pusa Bold and Varuna; and Pusa Agrani and Pusa Agrani at most seeds green stage was also found non-significant. At fully ripened growth stage, *cv*. Pusa Bold exhibited significantly higher total biomass followed by *cvs*. Varuna and Pusa Agrani. However, biomass partitioning into stem and siliquae did not differ significantly among different varieties. Similarly, total biomass production between *cvs*. Pusa Bold and Varuna also did not differ significantly. The differences in dry matter production among varieties could mainly be attributed in their genetic constitutions (Kumar *et al.*, 2008).

Yield attributes and yield

Crop sown on October 20 resulted into significantly higher siliquae plant^{-1} (198.7) and 1000-seeds weight (6.17g) followed by November 4 (185.4 and 5.73g, respectively) and November 19 (153.6 and 5.43g, respectively) sown crops (Table 3). These may be attributed to favourable environmental effect on plant growth and development. However, all sowing dates were failed to show significant differences for number of seeds siliqua^{-1}. Among different varieties, Pusa Bold produced significantly more number of siliquae (196.4 plant^{-1}), number of seeds siliqua^{-1} (13.4) and 1000 seed weight (6.37g) followed by *cvs*. Varuna (178, 12.5 and 6.0g, respectively) and Pusa agrani (163.4, 11.5 and 4.97g, respectively). However, number of seeds siliqua^{-1} between *cvs*. Pusa Bold and Varuna; and between *cvs*. Pusa Agrani and Varuna were found non-significant. The varietal differences in yield attributes among different varieties of *Brassica* species had also been reported by Kumar *et al.* (2008).

Table 3: Effect of different treatments on yield attributes, yield and oil content of Indian mustard

Treatments	No. of silique (plant^{-1})	No. of seeds (siliquae^{-1})	1000-seed weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)	Oil content (%)
Sowing dates								
20 Oct.	198.7	13.1	6.17	2009	4887	6895	29.3	42.1
4 Nov.	185.4	12.3	5.73	1597	4364	5961	27.2	40.5
19 Nov.	153.6	11.2	5.43	1224	4062	5286	23.0	38.1
S.Em±	5.5	0.5	0.08	73	129	187	0.32	0.32
CD (P =0.05)	22.0	NS	0.32	294	517	754	1.14	1.14
Varieties								
Pusa Agrani	163.4	11.5	4.97	1389	4347	5,735	38.7	38.7
Pusa Bold	196.4	13.4	6.37	1803	4828	6,630	40.0	40.0
Varuna	178.1	12.5	6.00	1638	4139	5,777	42.0	42.0
S.Em±	5.4	0.4	0.09	89	272	333	0.36	0.36
CD (P =0.05)	16.8	1.0	0.29	277	NS	NS	1.12	1.12

Data (Table 3) reveal that seed (2009 kg ha^{-1}), stover (4887 kg ha^{-1}), biological yield (6895 kg ha^{-1}) and harvest index (29.3%) were recorded significantly higher under October 20 sown crop followed by November 4 and November 19 sown crops. Consecutive 15 days delay in sowing from October 20 to November 4 and November 19 caused a loss in seed yield by 20.5 and 39.1%., respectively. The higher seed yield under October 20 sowing might be attributed to improved yield attributing characters *viz*., number of siliqua plant^{-1} and 1000-seeds weight. The favourable effect of early sowing (October 20) on sink component could be attributed to better development of the plants leading to increased bearing capacity due to optimum growth on account of favourable environmental conditions (Kumari *et al*., 2012). The reduction in seed yield under delayed sowing could be due to less translocation of current photosynthates towards reproductive parts, rapid initiation of inflorescence, flowering, fruiting and maturity, less number of siliquae and less siliqua filling duration because of non-fulfillment of temperature demands under late sowings. High temperatures and long days accelerated rapid maturity and lower the seed yield (Mondal *et al.*, 2011). Islam and Choudhary (2002) also mentioned that mustard plants under later sowings more rapidly fulfill the low temperature requirement to initiate earlier inflorescence and flowering. But early inflorescence restricts leaf production resulting in small plant, fewer pods bearing branches and finally low dry matter yield. As the level of dry matter in plants decide the yield potential and seed yields from late sown crops are greatly affected. Similarly, reduction in stover and biological yields under delayed sowing also occurred primarily due to the decreased in growth characters in terms of plant height, LAI and lower biomass buildup plant^{-1} (data not given). The slower growth on account of lower temperature during early vegetative growth phase and the overall shorter life span of crop caused reduction biomass production (Tobe *et al*., 2013). The significantly higher harvest index under early sowing of October 20 was due to proper vegetative growth and better and faster transfer of photosynthetic substances from source to the sink, and it consequently causes an increase in the yield and harvest index in early planting dates which was in accordance with the research of Kumari *et al*. (2012).

Among different varieties, Pusa Bold produced significantly higher seed yield (1803 kg ha^{-1}) followed by *cvs*. Varuna (1638 kg ha^{-1}) and Pusa Agrani (1389 kg ha^{-1}). However, *cvs*. Pusa Bold and Varuna were found non-significant. Cultivar Pusa Bold recorded 29.8% and 8.24% higher seed yield over Pusa Agrani and Varuna, respectively. The higher seed yield in *cv*. Pusa Bold was ascribed due to improved yield attributes *viz*., more number of siliqua plant^{-1}, more number of seeds (siliqua^{-1}) and 1000-seeds weight. The varietal differences in seed yield had also been reported by Adak *et al.* (2011) and Kumari *et al.* (2012). Varieties were failed to affect stover yield and biological yield significantly. The cultivar Varuna recorded significantly higher harvest index followed by *cvs*. Pusa Bold and Pusa Agrani. However, *cvs*. Varuna and Pusa Bold were at par. The varietal differences in harvest index had also been reported by Kumari *et al.* (2012).

Oil content

October 20 sown crop exhibited significantly higher content of oil (42.1%) followed by November 4 (40.5%) and November (38.1%). The longer duration of reproductive phase under October 20 sowing had a positive influence on the development of seed and therefore, increased oil content (Tobe *et al*., 2013). Among different varieties, Varuna recorded significantly higher oil content (42.0%) followed by *cvs*. Pusa Bold (40.0%) and Pusa Agrani (38.7%). The differences in oil content among different varieties could be attributed to their genetic constitution (Fasi *et al*., 2012).

It may be concluded from the study that the planting date of October 20 as compared to November 4 and November 14 enjoyed a significantly higher yield. Likewise, oil content was also higher under October 20 sown mustard crop. Among varieties, Pusa Bold was found to be most suitable for agro-climatic condition of Tikamgarh (M.P.) and exhibited 29.8 and 8.2% higher seed yield over *cvs*. Pusa Agrani and Varuna, respectively.

.

REFRENCES

Adak, Tarun, Narjary Bhaskar and Chakravarty, N. V.K. (2011) Response of *Brassica* to micro environment modification under semi-arid agro ecosystem. *Indian Journal of Agricultural Sciences.* **81** (8): 744–50.

Anonymous (2012) Agriculture Statistics at a Glance. Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India.

Fasi, V.T., Martin, R.J., Smallfield, B.M. and McKenzie, B.A. (2012) Sowing date effects on timing of growth stages, yield and oil content of potential biodiesel crops. *Agronomy New Zealand*. 42: 33-42.

Islam, N. and Choudhary, M. (2002) Effect of sowing date on yield and yield components of mustard and rapes. *Pakistan Journal of Agricultural Research*. **17** (2): 139-144.

Kumari, A., Singh, R.P. and Yeshpal (2012) Productivity, nutrient uptake and economics of mustard hybrid (*Brassica juncea*) under different planting time and row spacing. *Indian Journal of Agronomy*. **57** (1): 61-67.

Kumar, Rajesh, Singh, R.P. and Yeshpal (2008) Yield and quality of Brassica species as influenced by different dates of sowing and varieties. *Pantnagar Journal of Research.***6** (1): 6-11.

Lallu, R.S., Baghel, V.S. and Srivastava, S. B. L. (2010) Assessment of mustard genotypes for thermo tolerance at seed development stage. *Indian Journal of Plant Physiology.***15** (10): 36-43.

Mondal, M.R.I., Begum, F**.** and Saiyed, I.M. (2011) Effect of planting dates on seed and oil yield of rapeseed (*Brassica campestries* L.) genotype BCYS-03. *SAARC Journal of Agriculture.* **9** (1): 85-93.

Panda, B.B., Bandyopadhyay, S.K. and Shivay, Y.S. (2004) Effect of irrigation level, sowing dates and varieties on growth, yield attributes, yield, consumptive water use and water use efficiency of Indian mustard (*Brassica juncea*). *Indian Journal of Agricultural Sciences.* **74** (6): 331-342.

Robertson, J.A. and Morrison, W.H. (1979) Analysis of oil content of sunflower seed by NMR. *Journal of American Oil Chemistry Society*. **56**: 961–4.

Singh, S.K. and Singh, G. (2002) Response of Indian mustard (*Brassica juncea*) varieties to nitrogen under varying sowing dates in eastern Uttar Pradesh. *Indian Journal of Agronomy.***47** (2): 242-248.

Tobe, A., Hokmalipour, S.B. and Darbandi, M.H. (2013) Effect of sowing date on some phenological stages and oil contents in spring canola (*Brassica napus*, L.) cultivars. *Middle-East Journal of Scientific Research.* **13** (9): 1202-1212.

Uzun, B., Zengin, S. U., Furat and Akdesir, O. (2009) Sowing date effects on growth, flowering, seed yield and oil content of canola cultivars. *Asian Journal of Chemistry*. **21**: 1957-1965.