Journal of Oilseed Brassica, 9 (1) : 27-32, January 2018

Relative efficacy of natural resource use in Gobhi Sarson (*Brassica napus*) in Himachal Pradesh, India

Rajendra Prasad*, Anupam Sharma, Ruchi Sood and Vedna Kumari[1]

Department of Agronomy, Forages and Grassland Management,
[1]Department of Crop Improvement,
CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur-176062 HP, India
**Corresponding author: rprasad57@gmail.com*
(Received: 14 June 2017; Revised: 10 October 2017; Accepted: 28 October 2017)

Abstract

An experiment was conducted during *Rabi* 2010-11 to 2014-15 with an objective to quantify natural resource use by gobhi sarson in terms of heat use efficiency, radiation use efficiency and water use efficiency to facilitate the identification of varieties suitable for different sowing environments. In all the five varieties of gobhi sarson *viz*., GSL-1, ONK-1, HPN-1, HPN-3 and Hyola-401 (hybrid) sown on 20th Oct, 30th Oct and 10th Nov, it was observed that the days taken for completion of different phenological stages and their thermal units requirements from 90% siliquae filling to physiological maturity decreased with successive delay in sowing. The efficiency to use these resources vis-a-vis seed yield also decreased with delay in sowing.Water use efficiency was observed to be higher (3.0 to 5.3 kg/ha/mm) as compared to heat use efficiency (0.8 to 1.3 kg/ha/degreeday) and radiation use efficiency (0.5 to 0.8 kg/ha/MJ).The seed yield deceased with delay in sowing from 20th October (2.43 to 1.71 t/ha) to 10th November (1.79 to1.32 t/ha). The variety ONK-1, when sown on 20th and 30th October was found to be more efficient in respect of heat use (1.5 kg/ha/degree day) and water use (5.3 kg/ha/mm) as compared to other varieties studied.

Keywords: *Gobhi sarson, growing degree days (GDD), phenology, resource use efficiency, sowing dates*

Introduction

India occupies a prominent place in global oilseed scenario with 12-15% of area, 6-7% of vegetable oil production and 9-10 % of the total edible oil consumption and 13.6% of vegetable oil imports (Kumar, 2017). Oilseed crops are the second most important determinant of agricultural economy, next to cereals only. India is the 5th largest vegetable oil economy in the world next to USA, China, Brazil and Argentina accounting for 5.8% vegetable oil production (Anonymous, 2015). However, the domestic production of oilseeds is still insufficient to meet the edible oil demand in the country and more than 50% of domestic edible oil demand is being met through costly imports. India imported about 11.06 million ton of edible oil in 2013-14 (Kumar, 2017). Thus, increasing domestic oilseed production forms an important part of the strategy to enhance edible oil sustainability and reduce the dependence on imports. Among the oilseeds, rapeseed-mustard is an important *rabi* oilseed crop which accounts for 24.2% of the total oilseed production. In India, oilseeds are grown over an area of 25.8 million hectares with production of 27.5% million tons and productivity of 1060 kg/ha (Kumar, 2017). India has rich diversity of nine annual oilseed crops on account of diverse agro- ecological conditions (Meena *et al.*, 2014). The rapeseed-mustard crops faces numerous adverse conditions like high temperature at crop establishment and maturity stage, unpredictable cold spells, frost damage, fog and intermittent rains during crop growth, incidence of various pests and diseases that causes considerable yield losses where, the extent of yield reduction depends upon the degree, duration and timing of adverse conditions (Meena *et al.*, 2017).

Among the different species of rapeseed-mustard, gobhi sarson is the recently introduced crop of Himachal Pradesh. It has long crop duration with good yield potential, wider adaptability and possesses high oil content of good quality.This oilseed crop is becoming popular alternative to the farmers because it adds profitability to traditionally cereal based crop rotation. In this state, rapeseed-mustard crops are grown over an area of 11.37 thousand ha with total production of 6.37 thousand tons and productivity of 590 kg/ha (Anonymous, 2013-14). Hence, lower productivity than national average is a major cause of concern in Himachal Pradesh. Among the several reasons for reduced productivity, deficit precipitation, low air and soil temperature conditions of mid and high hills during initial phases of crop growth are important factors. Lack of sufficient rainfall as per requirements of crop, causes moisture stress at critical stages influencing many physiological processes which are required for proper plant growth and development (Piri and Sharma, 2007). Seed yield in mustard is positively correlated with total precipitation and negatively to the mean maximum daily temperature. Its growth is most vigorous in temperatures between 10°C and 30°C with an optimum temperature of around 20°C (Nuttal *et al*., 1992). In addition to air temperature, soil surface temperature and first few centimeters underneath, also determines the germination and emergence of the seeds. No germination takes place under scare soil moisture and extremely low or high temperature conditions (Prasad *et al.*, 2016). Keeping in view the futuristic changes in climate, it is imperative to quantify natural resource use in terms of Heat use efficiency (HUE), Radiation use efficiency (RUE) and Water use efficiency (WUE) in Gobhi Sarson.

Material and Methods

The field experiments were conducted under All India Coordinated Research Project on Agrometeorology (AICRPAM) during *Rabi*, 2010-11 to 2014-15 with five gobhi sarson varieties *viz.*, HPN-1, HPN-3, Hyola-401 (hybrid), ONK-1 and GSL-1under irrigated conditions. The experiment was laid out in randomized block design with threereplications in plot size of 4.5×3 m^2. The crop was sown on 20th October, 30th October and 10th November at the experimental farm, College of Agriculture, CSKHPKV, Palampur (32^{o} 6'N latitude, 76^{o} 3' E longitude and 1290 m above mean sea level) during each year. The soil of experimental site was silty-clay loam with pH of 5.7, organic carbon, 0.80%, available nitrogen, 284.8 kg ha^{-1}, available P, 16.3 kg ha^{-1}, and available K, 310.4 kg ha^{-1}. The recommended packages of practices were followed to raise the crop. Varieties *viz*., GSL-1 and ONK-1 generally matured in 145 to 185 days and attained height of 132 to186 cm while varieties viz., HPN-1, HPN-3 and Hyola-401 (hybrid), took 124 to 175 days and obtained height of 124 to 175 cm.

Meteorological data *viz*., maximum and minimum temperature, bright sunshine hours were recorded from Agro-meteorological observatory of CSK HPKV Palampur, HP, India.The dates of important phenological stages like emergence, first flower, 50% flowering, 90% siliquae filling and physiological maturity of different varieties sown on different dates were recorded at appropriate stages during each season.

The growing degree days (GDD) were calculated using Nuttonson (1955) method given as under:

$$GDD = \Sigma \frac{T_{max} + T_{min}}{2} - T_b$$

Where, T_{max} and T_{min} are daily maximum and minimum temperatures respectively and Tb is the base temperature (4.5^{o}C).

Heat use efficiency (HUE), Water use efficiency (WUE) and Radiation use efficiency (RUE) for seed yield were computed to compare the relative performance of different varieties using the following formulae:

Heat use efficiency (HUE) = Seed yield (kg/ha)/ accumulated GDD (degree days)

Water use efficiency (WUE) = Seed yield (kg/ha)/ actual evapotranspiration (mm)

Radiation use efficiency (RUE) = Seed yield (kg/ha)/ incident radiation (MJ)

Results and Discussion

Crop phenology and Heat Units:

Duration from sowing to first flower was lowest (72-86 days) in early sowing (20th Oct) and highest (89-101 days) in normal sowing (30th Oct) in all the varieties (Table 1). On the contrary, days taken to 50% flowering, 90% siliquae filling and physiological maturitygenerally reduced with each successive delay in sowing in all the varieties. The crop sown on 20th Oct took 170-182 days for physiological maturity while 30th Oct and 10th Nov sown crop took 163-176 days and 153-168 days, respectively. Owing to higher maximum and minimum temperatures, the earliest sown crop (20th Oct) took lesser number of days to complete emergence. While number of days to complete early reproductive phases (first flower to 50% flowering) and 50% flowering to 90% siliquae filling decreased in late sown crop (10th Nov). Also, GDD from sowing to occurrence of different phenological stages were highest (1630 degree days) in early sown crop. Keerthi *et al*. (2016) had also reported that 10 days successive delay in sowing from October 15 to November 15 reduced the crop duration by 1, 4 and 11 days, respectively and accumulated thermal units by 26, 65 and 163^{o}C days, respectively. Similar results were also reported by Singh *et al*. (2004).

Table 1: Days taken for the completion and accumulated growing degree days of different phenological stages

Phenologicalstages/ Sowing dates	GDD/Days taken to complete different Phenophases		
	20th Oct	30th Oct	10th Nov
HPN-1			
Emergence	111 (8)	145 (13)	136 (12)
First flower	746 (85)	753 (101)	675 (100)
50% flowering	942 (117)	848 (115)	807 (116)
90% siliquae filling	1257 (155)	1209 (151)	1119 (143)
Physiological maturity	1679 (182)	1603 (175)	1461 (166)
HPN-3			
Emergence	106 (8)	145(13)	152(14)
First flower	761 (86)	746(99)	660(97)
50% flowering	956 (119)	849(114)	800(115)
90% siliquae filling	1277 (153)	1141(147)	1091(141)
Physiological maturity	1682 (182)	1601 (175)	1503(166)
Hyola-401			
Emergence	115 (9)	152(14)	164(14)
First flower	751 (84)	720(96)	709(98)
50% flowering	945 (117)	887(119)	798(110)
90% siliquae filling	1270 (153)	1093(143)	1127(143)
Physiological maturity	1677 (182)	1612(176)	1508(168)
GSL-1			
Emergence	132 (11)	88 (7)	63 (6)
First flower	728 (85)	701 (89)	621 (85)
50% flowering	910 (117)	805 (105)	721 (100)
90% siliquae filling	1372 (165)	1231 (148)	1125 (139)
Physiological maturity	1576 (181)	1434 (163)	1317 (153)
ONK-1			
Emergence	148 (4)	137(13)	115(12)
First flower	695 (72)	724(96)	632(90)
50% flowering	905(109)	841(115)	740(108)
90% siliquae filling	1373 (158)	1275(158)	1174(149)
Physiological maturity	1536 (170)	1475 (172)	1376 (163)
Pooled			
Emergence	122 (8)	133 (12)	126 (12)
First flower	736 (82)	729 (96)	659 (94)
50% flowering	932 (116)	846 (114)	773 (110)
90% siliquae filling	1310 (157)	1190 (149)	1127 (143)
Physiological maturity	1630 (179)	1545 (172)	1433 (163)

Among all the varieties, ONK-1 took minimum number of days (170 days) to attain physiological maturity when sown on 20th Oct. On the other hand, varieties, HPN-1, HPN-3 and Hyola-401 (hybrid) took almost similar number of days (182 days) for physiological maturitywhile GSL-1 took 181 days to reach maturity in early sowing.

Values in parenthesis are days taken to complete different phenophase

The rate of development from emergence to anthesis in most of crop species depends upon photoperiod as well as the temperature (Angus *et al.,* 1981). Since the crop encountered higher temperature and sunshine hours in 20th Oct sowing, therefore, the crop accumulated adequate heat units in comparatively shorter period thus, resulted in early initiation of flowering. Further, due to lower temperature during reproductive phase in 20th Oct sown crop, longer grain filling period was availed, which resulted in better siliquae and seed development. However, in case of delayed sown crop (10th Nov), the temperatures encountered by crop during vegetative phase and early reproductive phase were quite low but, were higher during the later growth phase. Owing to these temporal temperature variations, the delayed initiation of flowering resulted in extended vegetative phase but shortened reproductive and maturity phases. Sahoo *et al.* (2000) and Poureisa and Nabipour (2007) also reported that quick rise in the air temperatures during reproductive stage shortened the seed filling period in rapeseed-mustard. Similar results were also reported by Mehnajtharranum *et al.* (2016).

Resource Use Efficiencies

Heat Use Efficiency (HUE)

Heat use efficiency determines the number of growing degree days required to produce unit amount of seed yield. It was observed that HUE was highest (1.1 to 1.5 kg/ha/degree days) in 20th Oct sown crop as compared to 10th Nov (0.8 to 1.0 kg/ha/degree days). This may be attributed to the fact that in Nov sown crop more number of heat units were utilized to attain physiological maturity. Singh (1999), Roy *et al.* (2005) and Chakravarty *et al.* (2006) also reported that less amount of heat units were recorded from sowing to maturity in *Brassica* crop as planting was delayed. Among the varieties, the highest HUE (1.5 kg/ha/degree days) was recorded in ONK-1 and lowest (1.1 kg/ha/degree days) each was observed in HPN-1 and Hyola-401 (hybrid) (Table2).

Table 2: Resource utilization efficiencies of *Brassica* varieties sown on different dates over the years

Varieties/ date of sowing	D_1- 20th October			D_2- 30th October			D_3- 10th November		
	HUE (kg/ha/^{o} days)	RUE (kg/ha/ MJ)	WUE (kg/ha/ mm)	HUE (kg/ha/^{o} days)	RUE (kg/ha/ MJ)	WUE (kg/ha/ mm)	HUE (kg/ha/^{o} days)	RUE (kg/ha/ MJ)	WUE (kg/ha/ mm)
HPN-1	1.1	0.7	4.1	0.9	0.6	3.5	0.8	0.6	3.5
HPN-3	1.2	0.8	4.6	1.0	0.6	3.7	0.9	0.6	3.4
Hyola-401(hybrid)	1.1	0.7	4.1	0.9	0.5	3.3	0.8	0.5	3.0
GSL-1	1.3	0.7	4.7	0.9	0.5	3.5	0.9	0.6	3.7
ONK-1	1.5	0.8	5.3	1.2	0.6	4.1	1.0	0.5	3.5

Radiation Use Efficiency (RUE)

It was observed that the RUE decreased with the delay in sowing. The highest RUE (0.7 to 0.8 kg/ha/MJ) was observed in early sowing dates (20th October) compared to later dates (30th Oct and 10th Nov). Similar results were obtained by Khichar *et al.* (2000) and Hundal *et al.* (2004) in mustard. Among the varieties, the highest RUE (0.8 kg/ha/MJ) was observed in ONK-1 and HPN-3 for early sowing dates. The efficiency of conversion of radiation into dry matter depends upon plant traits and environmental conditions (Hundal *et al.,* 2004).The comparison of radiation utilization efficiency of wheat and rapeseed-mustard indicates that rapeseed-mustard plant is photo-synthetically inefficient (Fig 1). Photosynthetic efficiency of irrigated rapeseed-mustard is nearly half to that of irrigated wheat and two-third of rain fed wheat. A plant in *brassica* sp. has been described as a model plant with 1-1.25 m plant height, 5-6 primary branches emerging at 30-45^o angle from main stem, 20 siliquae in top two branches and 15 siliquae each on lower three branches with 7-10 leaves and deep root system in order to use these resources efficiently (Bhargava *et al.,* 1984).

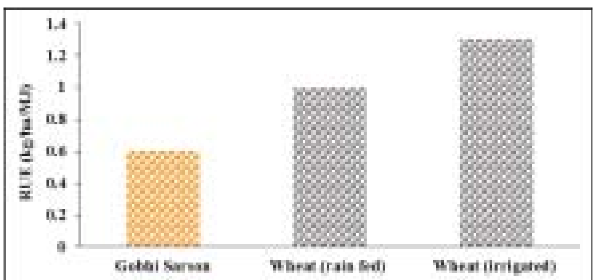

Fig. 1 Comparision of Radiation Use Efficiency of gobhi sarson and wheat

Water Use Efficiency (WUE)

Water use efficiency of Gobhi Sarson was found to decrease with delay in sowing ranging from 4.1 to 5.3 kg/ha/mm in 20th Oct to 3.0 to 3.7 kg/ha/mm in 10th Nov. Paramanik *et al.* (1996) had also observed that with delay in sowing from October to November water use efficiency of *B. carinata* decreased significantly. On the other hand, the optimum time of sowing can provide congenial conditions to have maximum light interception, best utilization of moisture and nutrients from early growth stage to seed filling stage in *B. juncea* (Keerthi *et al.*, 2016).Among the varieties, ONK-1 was found to be more efficient in terms of water use for early sowing (20th October)(5.3kg/ha/mm) and normal (30th Oct) (4.1kg/ha/mm) sowing dates as compared to later date (10th Nov) (3.5 kg/ha/mm) of sowing.

Seed Yield

Among all the varieties and sowing dates, the early sowing (20th) gave higher yield (2.4 to 1.7 t/ha) compared to later dates *i.e.* 1.83 to 1.12 t/ha in 30th Oct and 1.79 to1.32 t/ha in 10th Nov sowings (Table 3). The yield of the crop decreased with delay in sowing due to shortening of phenophases caused by higher temperatures that prevailed at seed filling and maturity phase. For obtaining yield >2 t/ha, rapeseed-mustard during vegetative phase require optimum maximum temperature of 20.3-24.4 °C, minimum 7.3-9.3°C and mean 14.4°C under mid hill conditions of Himachal Pradesh, India. The ambient air and soil temperatures during reproductive phase showed negative influence on the number of primary and secondary branches while they had positive influence on the plant height and number of siliquae per plant (Prasad *et al*., 2016). Lallu *et al.*, 2010 reported that one month delay in sowing from mid -October resulted in loss of 40.6% seed yield in mustard.Among the different varieties, Hyola-401 (hybrid) gave higher yields for early (2.43t/ha) and normal (1.83 t/ha) sowing while ONK-1 was superior for late sowing (1.79 t/ha).

Table 3: Effect of sowing dates on seed yield (t/ha) in different Gobhi Sarson varieties

Varieties/date of sowing	20th Octobersowing	30th Octobersowing	10th Novembersowing
HPN-1	2.04	1.57	1.37
HPN-3	1.71	1.12	1.69
Hyola-401(hybrid)	2.43	1.83	1.34
GSL-1	1.74	1.75	1.32
ONK-1	2.00	1.71	1.79
Mean	1.99	1.60	1.50

Conclusion

The study revealed that the weather based management plays an extremely useful role in managing weather vagaries and capitalizing benevolent effect of weather for increasing the production and productivity of crops.Sowing at optimum time with optimum environmental conditions is required for better expression of growth and yield in rapeseed.The results indicated that among all the efficiencies studied, water use efficiency was found to be highest. The heat use efficiency and water use efficiency of ONK-1 was found to be higheras compared to other varieties studied. Being photo-synthetically inefficient plant, the radiation use efficiency of rapeseed-mustard is much lower than wheat which might be responsible for low yields of the crop. Hence, vigorous efforts are required to be undertaken by Plant Breeders/ Crop Physiologists to develop an ideal plant type which can efficiently utilize radiation for source-sink conversion in Gobhi Sarson.

Acknowledgements

The authors are grateful to ICAR for providing the financial support and CSKHPKV, Palampur, HP, India for providing the necessary facilities to carry out the study.

References

Angus JF, Mackenzie DH, Morton R and Schafer CA. 1981. Phasic development in field crops. II. Thermal and photoperiod response of spring wheat. *Field Crop Res* **4**: 269-283.

Anonymous. 2015. Vision 2050. Directorate of Rapeseed-Mustard Research. ICAR, Sewar, Bharatpur, India.

Anonymous. 2013-14. Statistical Outline of Himachal Pradesh.Directorate of Land Records Government of Himachal Pradesh, India, pp165.

Bhargava SC, Tomar DPS and Sinha SK. 1984.Research and Development Strategies for Oilseed Production in India. ICAR, New Delhi, pp103.

Chakravarty NVK, Rao YVS, Neog P, Katiyar RK and Singh HB. 2006. Assessment of growth and yield of *Brassica*varieties under varying weather conditions through spectral behavior. *Brassica* **8**: 55-58.

Hundal SS, PrabhjyotKaur andMalikpuri SDS. 2004. Radiation use efficiency of mustard cultivars under different sowing dates. *J Agrometeorol* **6**: 70-75.

Keerthi P, Pannu RK, Singh R and Dhaka AK. 2016. Thermal requirements, heat use efficiency and plant responses of Indian mustard (*B. juncea*) for different levels of nitrogen under different environments. *J Agromet* **18**: 201-205.

Khichar ML, Yadav YC, Bishnoi OP and Niwas R. 2000. Radiation use efficiency of mustard as influenced by sowing dates, plant spacing and cultivars. *J Agromet* **2**: 97-99.

Kumar A. 2017. Oilseed Technologies Towards Self Sufficiency in Changing Climate Scenario. In: Proc 3rd Nat. Brassica conf. 16-18 Feb, 2017, ICAR-IARI, New Delhi, pp. 2-12.

Lallu RS, Baghel VS and Srivastava SBL. 2010. Assessmentof mustard genotypes for thermo tolerance at seeddevelopment stage. *Ind J Plant Physiol* **15**: 36-43.

Meena HS, Kumar A, Singh VV, Meena PD, Ram B and Kulshrestha S. 2017. Genetic variability and inter-relation of seed yield with contributing traits in Indian mustard (*B. juncea*). *J Oilseed Brassica* 8: 131-137.

Meena HS, Ram B, Kumar A, Singh BK, Meena PD, Singh VV and Singh D. 2014. Heterobeltiosis and standard heterosis for seed yield and important traits in *B. juncea*. *J Oilseed Brassica* **5**: 134-140.

Mehnajtharranum A, Singh R, Niwas R, Kumar N and Shalu Rani. 2016. Thermal time requirements of ten genotypes of *Brassica* species at Hisar. *J Agromet* **18**:131-133.

Nuttal WF, Moulin AP and Townley-Smith LJ. 1992. Yield response of canola to nitrogen, phosphorus, precipitation and temperature. *Agron J* **84**: 765–768.

Nuttonson MY. 1955. Wheat climate relationships and theuse of phenology in ascertaining the thermal and photothermal requirement of wheat. American Institute of Crop Ecology, Washington DC, USA, pp 388.

Paramanik SC, Singh NP, Singh S, Bandyopadhyay SK and Garnayar LM. 1996. Productivity and water use efficiency by Eithopian mustard (*Brassica carianata*) as influenced by time of sowing and irrigation. *Ann Agric Res* **17**: 1-8.

Piri I and Sharma SN. 2007. Effect of sulphur on yield attributes and yield of Indian mustard (*B. juncea*) as influenced by irrigation. *Indian J Agric Sci* **77**: 188-190.

Poureisa M and Nabipour M. 2007.Effect of planting date on canola phenology, yield and yield components. In: Proc. 12thIntrapeseed conf. 26-30 March, 2007, Wuhan, China, pp. 97-101.

Prasad Rajendra, Kumar Vijaya P and Ch. Srinivasa Rao.2016. Agrometeorology of Rapeseed-Mustard in Himachal Pradesh state of India, CSK HPKV, Palampur, Himachal Pradesh and CRIDA Hyderabad, India. pp 55.

Roy S, Meena RL, Sharma KC Kumar V, Chattopadhyay C, Khan SA and Chakravarty NVK. 2005. Thermal requirement of oilseed *Brassica* cultivars at different phenological stages under varying environmental conditions. *Indian J Agric Sci* **75**: 717-721.

Sahoo J, Pati P and Panigrahi R. 2000. Effect of sowing dates and row spacing on yield of toria.*Andhra AgricJ* **47**: 179-180.

Singh R, Rao VUM and Singh D. 2004. Effect of thermal regime on growth and development of Indian *Brassicas*. *J Agromet* **6**: 55-61.

Singh R. 1999. Crop weather studies in mustard under different environments. Ph.D. Thesis, CCS Haryana Agricultural University, Hisar, India.

●