The Bioscan 11(1): 279-283, 2016 (Supplement on Agronomy)
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

AGRO METEOROLOGICAL INDICES FOR BROWN SARSON (*BRASSICA RAPA* L.) SOWN UNDER DIFFERENT DATES OF SOWING IN TEMPERATE REGION OF KASHMIR

SABIA AKHTER*[1], LAL SINGH, AMAL SAXENA, RUBIA RASOOL, RUKHSANA JAN AND IRFANA SHOWQI[2]
[1]Division of Agronomy,
Sheri-Kashmir University of Agricultural Sciences and Technology of Kashmir - 190 025
[2]Division of Environmental Sciences,
Sheri-Kashmir University of Agricultural Sciences and Technology of Kashmir - 190 025
e-mail: sabiakhter77@gmail.com

KEYWORDS
Brown Sarson varieties
Date of sowing GDD
PTU
HTU and thermal indices

Received on :
07.08.2015

Accepted on :
10.01.2016

***Corresponding author**

ABSTRACT
A field experiment was conducted at KVK, Gandarbal, Shuhama, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir during rabi season 2011-12 to study the agro meteorological indices for brown sarson (*Brassica rapa*L.) sown under different dates of sowing in temperate region of Kashmir. The experiment was laid out in split plot design, consisted of three dates of sowing (1st October, 15th October, 30th October) in main plot and four varieties (KOS-1, Gulchein, Shalimar Brown Sarson-1 and P-3) in sub plot replicated four times. The objective of this experiment was to study the thermal regime of brown sarson crop and its impact on phenology and yield. The results revealed that days taken to physiological maturity and yield reduced significantly with delayed sowing. 1st October sown crop had significantly higher yield, total thermal units (^{o}C day) and the thermal use efficiency (kg ha^{-1}/^{o}C day) than 15th October and 30th October sown crop while the thermal units were more or less similar in all the varieties irrespective of the date of sowing but thermal use efficiency was more with variety P-3 as compared to Shalimar Brown Sarson-1, KOS-1 and Gulchein.

INTRODUCTION

Rapeseed and mustard are the major oilseed crops, traditionally grown everywhere, in the country due to their high adaptability in conventional farming systems. Rapeseed-mustard shares about 28 per cent of total oilseed production in India, with area of 6.32m ha and production of 6.12mt (Verma and Baigh, 2012). Brown sarson (*Brassica rapa* L.) is the only crop of the rapeseed-mustard group which fits well in the oilseed - paddy rotation prevailing in the valley of Kashmir and is the dominant *rabi* crop of the Kashmir valley. In Jammu and Kashmir the productivity of oilseed (brown sarson) is very low (6-8 q ha^{-1}) (ESJK, 2010-11). Of the several factors responsible for its low productivity, improper date of sowing, uneven topography of the valley and the farmers mainly grow the traditional varieties and land races which are not only low yielding but highly susceptible to biotic and abiotic stresses.

Time of sowing is very important for mustard production (Mondal *et al.,* 1999) as 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 (Iraddi, 2008). 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 (Pandey *et al.,* 1981). There is the variable response of rapeseed-mustard to different dates of sowing (Kumar *et al.,* 2007). Prevailing weather conditions during the whole crop growing season have direct bearing upon the phenological events of the crop which ultimately affect the crop yield.The concept of thermal and radiation use efficiency of different varieties may be useful to find out the proper recommendation for a specific area on the basis of their local weather condition.Temperature and light play a key role in influencing crop production (Meena *et al*., 2013). Canola growth from seedling emergence to blooming is controlled by photo-thermal factors and from blooming to maturity by temperature (Nanda *et al.,* 1996), so that each 1°C increase in temperature brings about 4.6 days shortening of the periods (Nanda *et al.,* 1994). The effect of temperature, determining the phenological behaviour during crop growth period, can be assessed by accumulated heat units (Gouri *et al*., 2005). The concept of heat units has been applied to correlate the phenological development of different crops to predict grain yield and physiological maturity of the crop (Swan *et al*., 1989). Temperature based agro meteorological indices such as Growing degree days (GDD), Heliothermal units (HTU) and Photo thermal units are based on the concept that real time to attain the phenological stage is linearly related to temperature in the range between base temperature and optimum temperature (Monteith, 1981). From the above points it is clear that varieties and date of sowing play a great role in the production of the rapeseed and mustard. Keeping in view of these facts, the present investigation was carried out to study the effect of date of sowing and varieties of brown sarson (*Brassica rapa* L.) on agro meteorological indices under temperate condition.

MATERIALS AND METHODS

A field experiment was conducted at KVK, Gandarbal, Shuhama, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir during *rabi* season 2011-12 situated at 34° 11′ N latitude and 74° 49′ E longitude at an altitude of 1639.5 meters above mean sea level. Experiment was laid out in split plot design and consisted of three dates of sowing, *viz*., 1st October, 15th October and 30th October in main plot and four varieties, *viz*., KOS-1, Gulchein, Shalimar Brown Sarson-1 and P-3 in sub plots replicated four times. The weather data were recorded at Agromet observatory of SKUAST-K, Shalimar Srinager and with the help of this data GDD, PTU, HTU were calculated at different phenological stages. Growing degree days at different phenological stages of brown sarson were calculated, using Wall *et al*. (1993) formula given below.

GDD = ″ $(T_{Max} + T_{Min})/2 - T_b$

T_{Max} = maximum of temperature of the day

T_{Min} = minimum of temperature of the day

T_b = base temperature of brown sarson, a temperature below which no development occurs for a given plant species. At temperatures above the minimum, plant development and growth rate increases as temperature increases up to optimum. While there is only limited plant growth at temperatures slightly above freezing but germination and seedling growth do occur at temperatures between 0 and 5°C. While the majority of previous research used a canola base temperature of 5°C, but a more accurate base temperature is from 0 to 5°C. For a cool season crop like canola grown in western Canada, 0°C is often the best base temperature for predicting development (Canola Council of Canada, 2012) and as the base temperature varies with stage and seasonal conditions of the crop so GDD was modified based on the prevailing weather conditions during crop growth period in accordance with the GDD/TT expression given below (Wang 1960).

Modification of GDD/TT expression

Method I

When $T_{av} < T_{base}$, then $T_{av.} = T_{base}$; when $T_{av.} > T_{UT}$, then $T_{av.} = T_{UT}$

Method II

when T_{max} or $T_{min} < T_{base}$, then T_{max} or $T_{min} = T_{base}$; T_{max} or $T_{min} > T_{UT}$, then T_{max} or $T_{min} = T_{UT}$

$T_{av.}$ = Average temperature $[(T_{Max} + T_{Min})/2]$

T_{base} = Base temperature

T_{max} = Maximum temperature

T_{min} = Minimum temperature

T_{UT} = Upper threshold temperature

So, 5°C, 0°C and 5°C was taken as base temperatures for brown sarson. Base temperature of 5°C was taken from sowing to rosette stage; 0°C as base temperature from rosette stage to flower bud initiation stage; 5°C as base temperature from flower bud initiation stage to harvest.

The helio-thermal units (HTU), the product of GDD and corresponding actual sunshine hours for that day were computed on daily basis and summed up.

Accumulated HTU = ″ GDD x Actual sunshine hours

Photothermal units (PTU), the product of GDD and corresponding day length for that day were computed on daily basis and summed up:

Accumulated PTU = ″ (GDD) x (length of the day/night)

Growing degree-days, helio thermal units and photo thermal units were accumulated from the date of sowing to a particular date of phenophase to give accumulated indices

Heat use efficiency (HUE), Photothermal use efficiency (PTUE), Heliothermal use efficiency (HTUE) for yield was computed using the formulae:

HUE (kg ha^{-1}/°C day) = [seed yield /Accumulated heat units]

PTUE (kg ha^{-1}/°C day) = [seed yield /APTU]

HTUE (kg ha^{-1}/°C day) = [seed yield/AHTU]

RESULTS AND DISCUSSION

Phenology

Table 1: Days taken to reach different phenological stages as influenced by date of sowing and varieties

Treatments	Emergence	Rosette stage initiation	Flower bud	Flower Initiation	80% plants start flowering	Physiological maturity
Sowing date						
1st October	6.4	46.6	131.3	159.8	165.5	225.1
15th October	7.4	57.06	122.1	156.9	160.4	221.4
30th October	12.4	67.31	121.5	145.3	150.9	208.7
SEm±	0.11	0.43	2.0	1.31	1.1	0.80
CD (p=0.05)	0.4	1.58	6.7	4.5	3.6	2.7
Varieties						
KOS-1	8.6	56.41	122.0	153.4	159.0	217.7
Gulchein	8.5	56.75	125.9	154.1	158.3	219.0
Shalimar Brown Sarson-1	8.5	57.66	125.5	154.4	159.3	218.6
P-3	9.1	57.25	127.1	153.6	159.0	218.3
SEm±	0.18	0.61	1.8	1.17	1.6	1.9
CD (p=0.05)	NS	NS	NS	NS	NS	NS

Table 2: Accumulation of Growing Degree Days (Heat units°C day) at various phenological stages as influenced by date of sowing and varieties

Treatment		Emergence	Rosette Stage	Flower Bud Initiation	50% Bolting	First Flower Open	80% plants start Flowering	80% plants completed Flowering	Maturity	Total
1^{st} October	KOS-1	76.8	281	260.8	22.7	99.8	16.7	116	350.9	1224.7
	Gulchein	65.5	292.2	267.1	12.7	101.7	14.5	127.5	352.9	1234.1
	Shalimar Brown Sarson-1	65.5	295.2	261.6	18.9	99.8	16.7	132.9	343.5	1234.1
	P-3	65.5	295.2	264.1	12.7	101.7	6.4	145	353.4	1244.0
15^{th} October	KOS-1	63.4	262.7	184.9	47.6	40.5	68.3	90.6	411.6	1169.6
	Gulchein	63.4	262.7	173.2	52.6	52.4	63.1	83.2	419	1169.6
	Shalimar Brown Sarson-1	63.4	266.2	187.3	41.7	45.7	67.5	86.1	429.8	1187.7
	P-3	71.1	258.5	165.2	57.1	59.4	48.8	106.9	409.5	1176.5
30^{th} October	KOS-1	59.1	218.6	167.8	22	91.2	35.8	50.4	441.6	1086.5
	Gulchein	59.1	214.7	186.6	8.8	89.4	27.8	58.4	475.8	1120.6
	Shalimar Brown Sarson-1	59.1	218.6	181.5	10.3	84.7	40.2	50.4	441.6	1086.4
	P-3	63.6	214.1	167.8	22	79.5	55	42.9	441.6	1086.5

Table 3: Accumulation of photothermal units at various phenological stages as influenced by date of sowing and varieties

Treatment		Emergence	Rosettestage Bud Initiation	Flower Bolting	50% Open	First Flower start Flowering	80% plants completed Flowering	80% plants	Maturity	Total
1^{st} October	KOS-1	892.00	3121.2	2716.7	250.1	1135.3	197.2	1449.2	3552.3	13314.00
	Gulchein	762.10	3251.1	2785.3	140.4	1156	170.2	1541.6	3629.9	13436.60
	Shalimar Brown Sarson-1	762.10	3282.7	2726.2	209	1135.3	197.2	1611	4433.3	14356.80
	P-3	762.10	3282.7	2753.3	140.4	1156	75.1	1753.4	4566.1	14489.10
15^{th} October	KOS-1	712.30	2788.1	1970.6	595.3	471.4	818.7	1753.4	5374	14483.80
	Gulchein	712.30	2788.1	1838.8	518.5	610.1	756.9	1113.6	5466	13804.30
	Shalimar Brown Sarson-1	712.30	2824	2001.5	580.7	533.2	810.9	1021.6	5620.8	14105.00
	P-3	798.00	2738.3	1752.4	647.2	693.4	585.7	1314.8	5260.6	13790.40
30^{th} October	KOS-1	639.70	2262.5	1850.9	253.8	1090.3	436.9	622.7	5780.7	12937.50
	Gulchein	639.70	2223	2062.5	102.2	1069.8	338.7	720.9	6245.2	13402.00
	Shalimar Brown Sarson-1	639.70	2262.5	2008.5	119.6	1012.9	490.9	622.7	5780.7	12937.50
	P-3	687.70	2214.5	1850.9	253.8	948.5	670.9	530.5	5780.7	12937.50

Table 4: Accumulation of Heliothermal units at various phenological stages as influenced by date of sowing and varieties

Treatment		Emergence	Rosette Stage	Flower Bud Initiation	50% Bolting	First Flower Open	80% plants start Flowering	80% plants completed Flowering	Maturity	Total
1^{st} October	KOS-1	533.70	1694.40	933.00	30.40	430.00	91.60	397.50	2034.30	6144.90
	Gulchein	462.00	1766.40	946.00	17.70	423.60	78.50	469.60	2013.20	6177.00
	Shalimar Brown Sarson-1	462.00	1785.00	927.10	17.70	430.00	91.60	514.20	2049.40	6277.00
	P-3	462.00	1785.00	927.10	17.70	423.60	98.10	594.30	1972.50	6280.30
15^{th} October	KOS-1	456.30	1110.80	612.30	252.80	197.80	179.60	521.70	2436.90	5768.20
	Gulchein	456.30	1110.80	552.60	259.60	250.70	179.60	464.70	2493.90	5768.20
	Shalimar Brown Sarson-1	456.30	1131.50	620.60	223.90	197.80	183.20	518.10	2517.30	5848.70
	P-3	498.00	1090.00	526.10	265.40	250.70	179.60	611.70	2346.80	5768.30
30^{th} October	KOS-1	253.20	796.40	610.70	99.70	281.30	214.30	303.80	2650.70	5210.10
	Gulchein	253.20	779.10	706.70	29.80	274.80	165.50	352.60	2832.00	5393.70
	Shalimar Brown Sarson-1	253.20	796.40	687.10	30.70	270.40	217.90	303.80	2650.70	5210.20
	P-3	257.30	792.40	687.10	99.70	277.70	217.90	303.80	2650.70	5286.60

The early sown (1^{st} October) crop took more number of days for flowering and maturity compared to normal (15^{th} October) and late sowing (30^{th} October). The early, normal and late sown brown sarson matured in 225, 221 and 209 days respectively under temperate conditions of Kashmir valley (Table 1). Late sown crop took more days to complete early stages viz., emergence and rosette stage and it may be attributed to the decrease in mean temperature, while after rosette stage the late sown crop took less number of days to flower bud initiation, flowering and physiological maturity. It may be due to higher temperature after rosette stage in late sown crop which fulfil the requirement of growing degree days and thermal units of crop for achieving different phenological stages in lesser days as compared to early sown crop when day and night temperature was lower at later stages and was in agreement with the findings of Hokmalipour *et al.* (2011) who reported that early sowing reached to maturity later as compared to delayed sowing dates. There was no significant difference between varieties in days taken to different phenological stages. It may be attributed to their same maturity period. Similar results were obtained by Gunasekera *et al.* (2001) who found that Oscar and Monty varieties of mustard had no significant difference in days taken to different phenological stages.

Agro meteorological indices

The agro meteorological indices (GDD, HTU and PTU)

Table 5: Yield kg ha-1, total Heat use efficiency (HUE), Photothermal use efficiency (PUE) and Heliothermal use efficiency (HUE) (kg ha-1/oC day)as influenced by date of sowing and varieties

Treatment		Seed yield kg ha^{-1}	HUE	PTUE	HTUE
1st October	KOS-1 GulcheinShalimar Brown Sarson-1P-3	1578	1.29	0.12	0.26
		1774	1.44	0.13	0.29
		1823	1.48	0.13	0.29
		1913	1.54	0.13	0.31
15th October	KOS-1 GulcheinShalimar Brown Sarson-1P-3	1287	1.10	0.09	0.22
		1225	1.05	0.09	0.21
		1384	1.17	0.10	0.24
		1555	1.32	0.11	0.27
30th October	KOS-1 GulcheinShalimar Brown Sarson-1P-3	781	0.72	0.06	0.15
		485	0.43	0.04	0.09
		573	0.53	0.04	0.11
		805	0.74	0.06	0.15

accumulated for attaining different phenophases are presented in Tables 2, 3 and 4. The early sown crop required more temperature based agro meteorological indices such as growing degree days (GDD), heliothermal units (HTU) and photo thermal units for various phenological stages in comparison with normal and late sown crop and it might be due to availability of longer growth period for early sown crop than delayed sowing, similar results were obtained by Kingra and Kaur (2012) and Tharranum *et al.* (2009) who observed that earlier sown crop availed higher cumulated heat units at physiological maturity in groundnut and brassica species than delay sowing. Significantly maximum seed yield was obtained with 1st October sowing than 15th and 30th October sowing (Table 5), it might be due to the fact that the early sown crop got longer time period to utilize available resources and favourable temperature at later growth stages while shorter time available for the late sown crop to utilize the available growth factors (light, nutrients, moisture etc.). Similar results were obtained by Dinda *et al.* (2015) who reported higher seed yield in rapeseed and mustard with early sowing (20th October) than second (5th November) and third sowing (20th November).The higher heat use efficiency, heliothermal use efficiency and photothermal use efficiency were more in early sowing than 15th and 30th October sowing. It might be due to higher seed yield in early sowing which increases the thermal efficiency. These results are in conformity with the results of Kingra and Kaur (2012) who reported higher heat use efficiency with early sowing than delay sowing. Among varieties these agro meteorological indices such as accumulated growing degree days (AGDD), heliothermal units (AHTU) and photothermal units (APTU) were more or less similar in all varieties and it might be due to similarity in days taken to physiological maturity. However, heat use efficiency, photothermal use efficiencyand heliothermal use efficiency were recorded more with variety P-3 (1.54, 0.13, 0.31 kg ha^{-1}/^{o}C day) as compared to Shalimar Brown Sarson-1 (1.48, 0.13, 0.29kg ha^{-1}/^{o}C day), Gulchein (1.44, 0.13, 0.29 kg ha^{-1}/^{o}C day) and KOS-1 (1.29, 0.12, 0.26 kg ha^{-1}/^{o}C day) respectively**.** The higher heat use efficiency, heliothermal use efficiency and photothermal use efficiency with variety P-3 might be due to higher seed yield (Table 5). These results are in conformity with the findings of Khushu *et al.* (2008).

REFERENCES

Canola Council of Canada 2012. Canola Council of Canada, book name: Temperature, Frost, Hail. Chapter 5.

Dinda, N. K., Ray, M. and Sarkar, P. 2015. Effect of sowing date vis-a-vis variety of rapeseed and mustard on growth, yield and aphid infestation in gangetic plains of west Bengal. *The Ecoscan*. **9(1&2):** 21-24.

Economic Survey 2010-11. Economic Survey of Jammu and Kashmir. pp. 110-102.

Gouri, V., Reddy, D. R., Rao, S. B. S. N. and Rao, A. Y. 2005. Thermal requirement of rabi groundnut in southern Telangana zone of Andhra Pradesh. *J. Agrometeorology*. **7(1):** 90-94.

Gunasekera, C. P., Martin, L. D., Walton, G. H. and Siddique, K. H. M. 2001. Indian mustard (*Brassica juncea*L.) - A Promising oil seed crop for low rainfall cropping regions of Western Australia**.** In: "12th Australian Research Assembly on Brassicas".

Hokmalipour, S., Tobe, A., Jafarabad, B. and Darbandi, M. H. 2011. Effect of sowing date on dry matter accumulation trend, yield and some agronomic characteristics in canola (*Brassica napus* L.) cultivars. *World Applied Sci. J.* **19(7):** 996-1002.

Iraddi, V. S. 2008. Response of mustard (*Brassica juncea* L. Czernj and Cosson) Varieties to date of sowing and row spacing in Northern transition zone of Karnataka. *Thesis Submitted to the University of Agricultural Sciences, Dharwad In partial fulfilment of the requirements for the Degree of Master of science (Agriculture) In Agronomy*. pp. 55-81.

Khushu, M. K., Naseer-Ur- Rahman, Singh, M., Tiku, A. K. and Bali A. S. 2008. Thermal time indices for some mustard genotypes in the Jammu region. *J. Agrometerol.* **10(2):** 224-227.

Kingra, P. K. and Kaur, P. 2012. Effect of Dates of Sowing on Thermal Utilisation and Heat Use Efficiency of Groundnut Cultivars in Central Punjab. *J. Agricultural Physics.* **12(1):** 54-62.

Kumar, G., Adak, T., Chakravarty, N. V. K., Chamola, R., Katiyar, R. K. and Singh, H. B. 2007. Effect of ambient thermal on growth and yield of *Brassica* cultivars. *Brassica*. **9(1-4):** 47-52.

Meena, R. S., Yadav, R. S. and Meena V. S. 2013. Heat unit efficiency of groundnut varieties in scattered planting with various fertility levels. *The Bioscan*. **8(4):** 1189-1192.

Mondal, R. I., Biswas, M., Hydar A. M. K. and Akbar, M. A. 1999. Response of rapeseed genotype Dhali to seed rate and seeding date. *Bangladesh J. Agricultural Research.* **24(1):** 83-90.

Monteith, J. L. 1981. Climate variation and growth of crops. *Quat. J. Royal, Meterol. Soc.* **107:** 602-607.

Nanda, R. S., Bhargava, C. and Tomar, D. P. S. 1994. Rate and duration of siliqua and seed filling period and their relation to seed yield in Brassica species. *Ind. J. Agricul. Sci.* **64(4):** 227-232.

Nanda, R. S., Bhargava, C., Tomar, D. P. S. and Rawson, H. M. 1996. Phenological development of *Brassica campestris*, *B. juncea, B. napus*and *B. carinata*grown in controlled environments and from 14 sowing dates in the field. *Field. Crops. Res.* **46(1-3):** 93-103.

Pandey, B. P., Sirvastava, S. K. and Lal, R.S. 1981. Genotype and environment interaction in lentil. *Lens*. **8:** 14-17.

Swan, J. B., Schneider, E. C., Moncrief, J. E., Paulson, W. H. and Peterson, A. E. 1989. Estimation of crop growth yields and grain moisture from air growing degree days and residue cover. *Agron. J.* **79:** 53-60.

Tharranum, M., Singh, R., Niwas, R. and Singh, D. 2009. Thermal time requirements and life span of Brassica species under different growing environments. Abstracts and Souvenier 4th National Seminar on Agrometreology-Needs, Approaches and linkages for rural development, CCS HAU, Hisar. p. 34.

Verma, K. C. and Baighm. A. 2012. Response of phosphorus and molybdenum on yield and quality attributing characters of indian mustard (brassica juncea l. czern&coss). *The Bioscan* **7(3):** 437-440.

Wall, D. A., Friesen, G. H. and Bhati, T. K. 1993. Wild mustard (sinapsisarvensis) competition with navy beans. *Can. J. Plant Sci*. **73:** 1309-1313.

Wang, J. Y. 1960. A critique of heat unit approach to plant response studies. *Ecology*. **41:** 785-790.