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Short Comminucation

Effect of temperature on phenology and yield of rapeseed in mid hill region of Himachal Pradesh

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India is the largest rapeseed-mustard growing country in the world occupying first position in area and second in production (Anonymous, 2015).Gobhi sarson (*B. napus*L.) is the new emerging oilseed crop having limited area of cultivation in Himachal Pradesh. The crop in this state is grown over an area of 11.37 thousand hectare with the total production of 6.37 million tones (Anonymous, 2014). Despite wider adaptability under varied agro climatic conditions, the yield may fluctuate due to various biotic and abiotic stresses. Weather is very important factor among the various abiotic stresses which influence growth and yield of the crop. Response of the crop is therefore, largely governed by changes in growing environment such as date of sowing, rainfall and temperature.

Delay in sowing affects growth and causes early maturity resulting in drastic yield reduction mainly due to rising temperature during maturity phase. Plants have a definite temperature requirement to attain phenological stages. Heat units have frequently been used as a weather based parameter for assessing crop phenology and yield (Warthington and Hatchinson 2005). Gupta *et al*. (2017) has found the shortening of the duration of the late sown mustard crop due to higher temperature during reproductive phase of the crop. Being a thermo-sensitive crop, choice of suitable variety for different seeding time further gets prime importance. In present investigation, the phasic requirement of temperature and heat units were evaluated in five varieties *vis-à-vis* their yield performance.

Field experiments were conducted under All India Coordinated Research Project on Agrometeorology (AICRPAM) during 2010-11to 2014-15 with three gobhi sarson varieties viz., HPN1, HPN3 and Hyola PAC 401 under irrigated conditions. Two more varieties viz., ONK1 and GSL1 were added during 2012-13 to 2014-15. The experiment was laid out in randomized block design with three replications. The crop was sown on 20th October, 30th October and 10th November at the experimental farm, College of Agriculture, CSKHPKV, Palampur which is situated in mid hills of Himachal Pradesh (latitude: 32° 6'N,longitude: 76° 3'E and altitude : 1290 m above MSL). 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 crop was raised by following the recommended package of practices. The meteorological data viz., maximum and minimum temperatures were recorded from Agro-meteorological observatory of CSK HPKV Palampur.The growing degree days (GDD) also called as heat units 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 temperature, respectively and Tb is the base temperature (4.5°C). The growing degree days were then accumulated for different phenological stages.

The perusal of data revealed that the days taken for different phenological stages varied with date of sowing (Table 1).All the varieties sown on 20th October had accumulated higher heat units at 50 per cent flowering till physiological maturity as compared to the other sowing dates. Among the varieties, HPN1, HPN3 and Hyola PAC 401 sown on 20th October took almost similar number of days and heat units for attaining these phenological stages. For example, these varieties took 117-119 days and 942-956 °daysfor attaining 50 per cent flowering stage.

Early sown crops, in general took less number of days and heat units to complete emergence and in later stages viz., 50 per cent flowering to physiological maturity, took more number of days and heat units as compared to the timely and late sown dates. It was due to exposure to higher temperature during emergence and lower temperature during flowering stage in early sown crops which was not able to meet the thermal requirement of the crop for attaining different phenological stages thus taking more number of

Table1: Days and accumulated growing degree days taken for completion of different phenological stages and yield of different enltivan gobhi sarson sown on different dates (Mean ever year 2010-11 to 2014-15)

Phenological stages	Varieties	Days taken			AGDD		
		20th Oct	30th Oct	10th Nov	20th Oct	30th Oct	10th Nov
Emergence	GSL-1	11	7	6	132	88	63
	HPN-1	8	13	12	111	145	136
	HPN-3	8	13	14	106	145	152
	Hyola-401	9	14	14	115	152	164
	ONK-1	4	13	12	148	137	115
First flower	GSL-1	85	89	85	728	701	621
	HPN-1	85	101	100	746	753	675
	HPN-3	86	99	97	761	746	660
	Hyola-401	84	96	98	751	720	709
	ONK-1	72	96	90	695	724	632
50% flowering	GSL-1	117	105	100	910	805	721
	HPN-1	117	115	116	942	848	807
	HPN-3	119	114	115	956	849	800
	Hyola-401	117	119	110	945	887	798
	ONK-1	109	115	108	905	841	740
90% siliquae filling	GSL-1	165	148	139	1372	1231	1125
	HPN-1	155	151	143	1257	1209	1119
	HPN-3	153	147	141	1277	1141	1091
	Hyola-401	153	143	143	1270	1093	1127
	ONK-1	158	158	149	1373	1275	1174
Physiological Maturity	GSL-1	181	163	153	1576	1434	1317
	HPN-1	182	175	166	1679	1603	1461
	HPN-3	182	175	166	1682	1601	1503
	Hyola-401	182	176	168	1677	1612	1508
	ONK-1	170	172	163	1536	1475	1376
Yield (kg ha^{-1})	GSL-1	1809.1	1325.3	1050.0			
	HPN-1	1559.9	1624.0	1147.2			
	HPN-3	1740.5	1529.8	1456.6			
	Hyola-401	1670.5	1501.9	1218.2			
	ONK-1	2044.0	1454.0	1122.3			

days as compared to late sown crop when day and night temperature were higher. Khushu *et al.* (2008) also reported that in mustard the duration of each phenophase as well as days to maturity in general were shortened as the sowing was delayed.

Results revealed that all cultivars sown 20th October produced maximum yield except HPN-1, which produced maximum yield in 30th October sowing (Table 1). With every 10 days delay in sowing from 20th October, the reduction in seed yield was observed in all the varieties except HPN-1. The reduction was found to be 10.1-28.9 and 10.1-45.1 per cent, respectively with overall reduction of 30.2 per cent up to 10th November in 20 days delay in sowing. Similar reduction in seed yield to the extent of about 45 per cent with one month delay in sowing was also observed by Shastry and Kumar (1981).

The minimum and maximum temperatures had a profound influence on the seed yield of the gobhi sarson, particularly during flowering and siliquae development phases. The average temperatures of 19.8, 14.4, 10.2 and 15.1°C during emergence, vegetative, reproductive and maturity phase,respectively were found to be optimum for maximum yield under Palampur conditions (Kulshrestha, 2014). The minimum temperature less than 13°C and maximum temperature between 29 to 31°C during flowering and siliquae development phase were found favourable in Hisar (Anonymous, 2001). It further indicates that lower average air temperatures (<15.4°C) during vegetative and (<13°C) reproductive phases are constraints for obtaining higher yields of gobhi sarson under mid hill conditions of Himachal Pradesh which suggests that this crop can perform better under temperature conditions of 15.7 to 17.2°C.

The study indicates that the crop sown on early date took more number of days and heat units to attain different phenological stages. The mean maximum temperatures during the reproductive phase were found to be critical in deciphering the yields of gobhi sarson. The early sowing proved beneficial under mid hill conditions of Himachal Pradesh for obtaining higher seed yields and escaping the attack of aphids.

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