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Agro-meteorology of Indian Brassicas

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सार - सरसों की फसल की बढ़वार और उसकी पैदावार पर मौसम प्राचलों के पड़ने वाले प्रभावों का अध्ययन करने के लिए सी.सी.एस.,एच.ए.यू. हिसार के अनुसंधान फार्म में दो मौसमों की फसलों (1996-97 और 1997-98) पर खेत पर आधारित प्रयोग किए गए हैं। इनसे प्राप्त हुए परिणामों से अधिकतम तापमान और तेज धूप के घटों की अवधि बढ़ने से पौधों के पत्तों की बढ़वार (एल.ए.आई.) का भी पता चला है। दिन के समय तापमान में हुई वृद्धि के परिणामस्वरूप फसल के उगने के दौरान जैवभार का संचयन अपेक्षाकृत अधिक होने का पता चला है किंतु यह प्रवृति फसल के पकने के दौरान विपरीत पाई गई है1 पौधों की पूरी अवस्था के दौरान वाष्पोत्सर्जन दर में हुई वृद्धि से ब्रैसिका में जैवभार के संचयन में बढ़ोतरी का पता चला है। तथापि बाद में फसल के पकने के दौरान वाष्पोत्सर्जन की दर में वृद्धि के परिणामस्वरूप जैवभार संचयन क्षीण पाया गया है। इसके अलावा, पैदावार की मात्रा को निर्धारित करने में फसल के उगने के दौरान कुछ महत्वपूर्ण प्राचलों (अधिकतम और न्यूनतम तापमानों, पात्र वाष्पन और प्रातःकालीन सापेक्षिक आर्द्रता) के परिणामों की भूमिका निर्णायक पाई गई है, जो फसल की पैदावार से संबंधित विभिन्न विशेषताओं में सबसे अधिक महत्वपूर्ण है। फसल के उगने के दौरान वर्षा का पैदावार और पैदावार से संबंधित विशेषताओं के साथ या तो कोई संबंध पाया ही नहीं गया है अथवा नकारात्मक संबंध पाया गया है क्योंकि सिंचाई से प्रचुर नमी मिल जाने के कारण फसल के लिए जल की कमी का पता नहीं चला है।

ABSTRACT. Field experiment was conducted for two crop seasons (1996-97 & 1997-98) at CCS, HAU, Hisar research farm to study the effect of weather parameters on growth and yield of mustard. The results indicated that an increase in maximum temperature and duration of sunshine hours resulted in increased leaf area index (LAI). The increase in daytime temperature resulted in higher biomass accumulation during vegetative phase, but the trend was reversed during physiological maturity. The biomass accumulation in brassicas increased with increase in evaporation rate during the grand growth period. However, latter on during the physiological maturity, increase in evaporation rate resulted in decline of biomass accumulation. Further, it was noted that the magnitudes of some important weather parameters (maximum and minimum temperatures, pan evaporation and morning relative humidity) during the vegetative phase of crop played decisive role in deciding the quantum of seed yield which is a resultant of various yield attributes. The rainfall during the crop growing season either have no association or had a negative relationship with yield and yield attributes because crop never experienced water stress as abundant moisture was made available through irrigation.

Key words – Brassica, Temperature, Rainfall, Sunshine, Relative humidity, Biomass, LAI, Seed yield, Yield attributes, Vegetative phase, Reproductive phase, Maturity phase.

1. Introduction

Agriculture is the most important primary economic activity pursued throughout the world and is entirely dependent on weather. The knowledge of optimum weather conditions specific to various phases of crop growth coupled with the knowledge of past weather over a number of years help us to characterise the growing season for a crop over a given region. The rate of many physiological processes occurring in plant is markedly influenced by temperature. Temperature may have differential quantitative and qualitative effects on growth and yield of a crop, over and above is the influence on flowering and crop production. Another important weather factor in crop production is solar radiation (the source of energy for photosynthesis). The accumulation of biomass is essentially a linear function of accumulated photosynthetically active radiation (PAR) by crop canopy, which is a function of leaf area index (Hughes and Keatinge, 1983). Mustard is the most widely grown Brassica species in Indian subcontinent. Optimum time of sowing and plant density, are the two most important

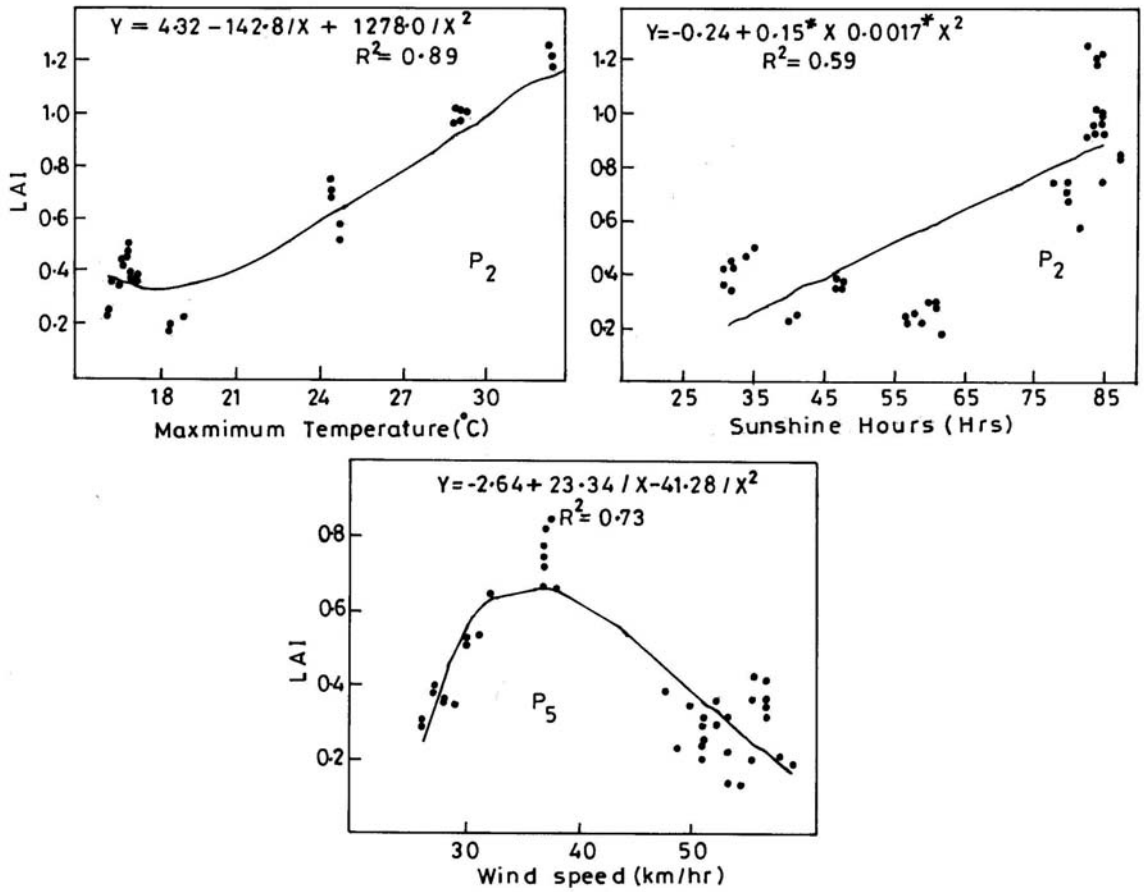

Fig. 1. Effect of different weather elements on LAI

agronomic non-monetary input, which play a pivotal role in achieving the potential yield of a crop. These two inputs decide the environmental conditions, the crop is likely to encounter during its growth. The role of different weather parameters on growth and development of crops remains oblivious. In view of the potential significance of crop-weather relationships, the present field study was carried out to study the effect of weather parameters encountered under different growing environments on growth and yield of mustard crop.

2. Materials and methods

The experiment was conducted during *rabi* (winter) seasons of 1996-97 and 1997-98 at the research farm of CCS Haryana Agricultural University, Hisar (29^o 10′ N, 75^o 46′ E and 215.2m a.m.s.l.). The experiment was laid out in split-plot design with three replications. The treatment combinations comprised of three sowing dates (5 Oct , 19 Oct and 5 Nov in 1996-97 and 24 Nov, 4 Dec and 16 Dec in 1997-98), two plant spacing (30cm × 15cm and 40cm × 20cm) and four varieties (Varuna, RH-30, Laxmi and BSH-1). The variation in sowing dates was kept to create different crop growing environments. Full dose of phosphorus (40 kg/ha) and half of nitrogen (40 kg/ha) was applied at the time of sowing and remaining half of nitrogen (40 kg/ha) was applied after first irrigation. The crop was inspected regularly at frequent interval (2 to 3 days) to follow the phenological events closely. From these observations, emergence (P_1), first flower appearance (P_2), 50% flowering (P_3), start of seed filling (P_4), end of seed filling (P_5) and physiological maturity (P_6) were identified. Five plants were taken randomly for measuring leaf area index (LAI) and dry matter accumulation at various growth stages. Leaf area of plants selected for biomass observation was measured with the help of leaf area meter (LICOR, LI-3000). The yield and yield attributing characters such as number of siliqua/m^2, number of seeds/siliqua, 1000-seed weight (test weight), seed yield/m^2 and seed yield (kg/ha) were recorded at harvest. Daily observation of meteorological parameters *viz.*, maximum (T_{max}) and minimum (T_{min})

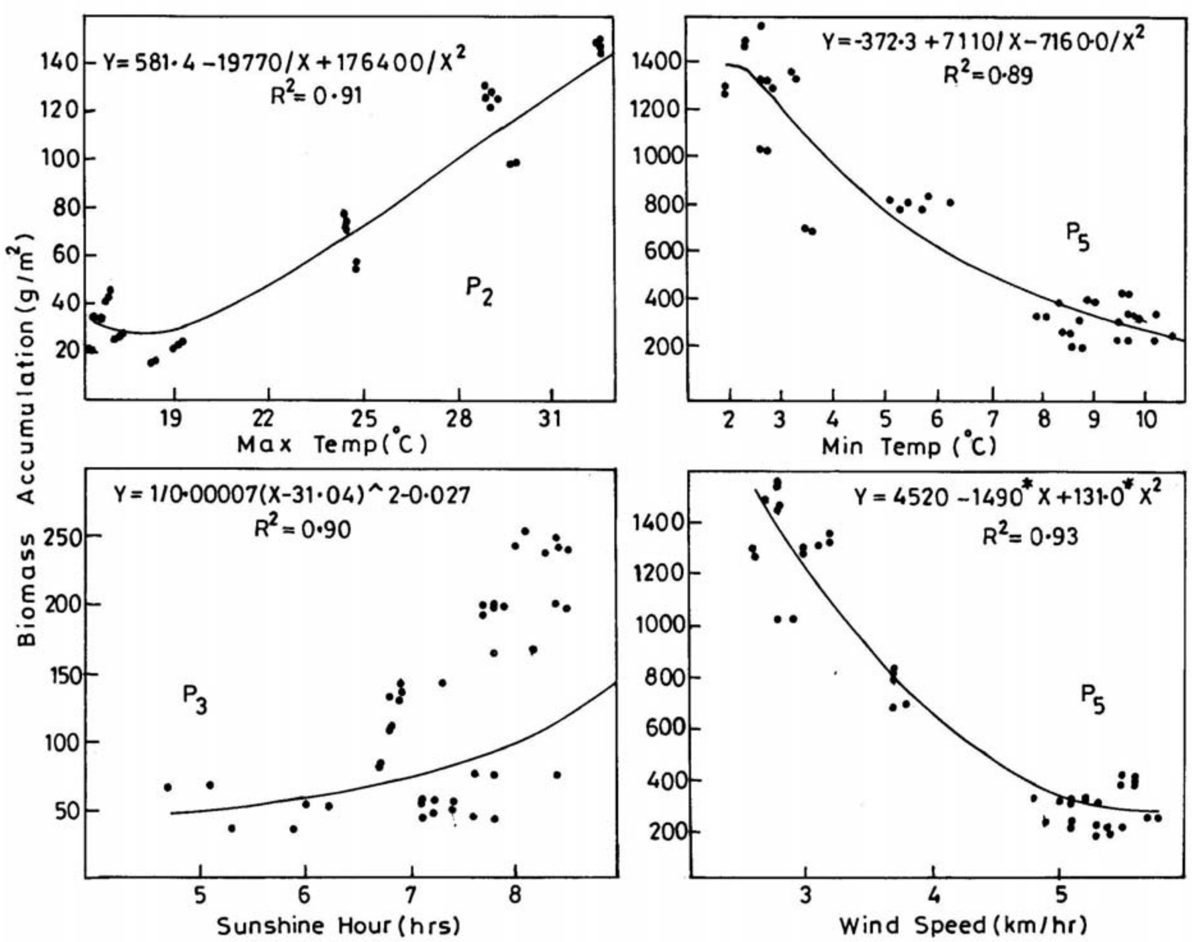

Fig. 2. Effect of different weather elements on Biomass accumulation

temperatures, morning (RH_m)and evening (RH_e) humidity, bright sunshine hours (SS), pan evaporation (PE), wind speed (WS) and rainfall (Rain) were recorded at agro-meteorological observatory situated at a distance of 10 m from the experimental site.

3. Results and discussion

3.1. *Effect of weather elements on LAI*

The LAI increased with increase in maximum temperature during the grand growth period spread over P_2 and P_3 phases of crop growth (Fig.1). The maximum temperature during these phenophases varied between 18 to 33° C and was within the cardinal limits for growth of oilseed *brassicae*. Recent studies reviewed by Monteith and Elston (1983) indicate that the duration of leaf expansion is closely related to temperature. Bose (1973) found that higher temperature was responsible for increased leaf area during vegetative stage. Hence, the increase in LAI with increase in maximum temperature is consistent. Further, LAI also increased with increase in duration of sunshine hours (Fig.1), which could result because of the persistent higher photosynthetic rate over a longer duration owing to extended sunshine duration leading to faster cell division and elongation as plenty of energy was available in the leaf lamina itself. The influence of sunshine and maximum temperature was more or less similar as an increase in these parameters during the period from sowing to commencement of elongation will have beneficial effect on all growth and development parameters. However, LAI decreased with increase in wind speed towards end of seed filling phase (Fig.1), which can be expected because of energy loss and faster leaf abscission owing to higher wind speed recorded during this phase of crop growth.

TABLE 1

Correlation coefficients between weather parameters and seed yield and its attributes at various growth stages in *brassica*

Weather parameters	No. of seeds/siliqua					1000-seed weight				
	P_2	P_3	P_4	P_5	P_6	P_2	P_3	P_4	P_5	P_6
T_{max}	0.72	0.31	-0.14	-0.63	-0.66	0.77	0.45	-0.08	-0.50	-0.49
T_{min}	0.69	-0.23	-0.72	-0.79	-0.70	0.62	-0.10	-0.67	-0.76	-0.55
RH_m	-0.72	-0.35	-0.16	0.38	0.53	-0.77	-0.43	-0.20	0.25	0.43
RH_e	-0.47	-0.75	-0.73	-0.62	0.09	-0.63	-0.75	-0.68	-0.74	-0.01
WS	-0.13	-0.35	-0.82	-0.73	-0.68	-0.36	-0.16	-0.66	-0.77	-0.60
SS	0.47	0.35	-0.01	0.03	-0.06	0.63	0.42	-0.05	0.28	-0.20
PE	0.72	0.37	-0.55	-0.75	-0.66	0.76	0.49	-0.43	-0.61	-0.55
Rain	-0.47	-0.35	-0.10	-0.62	0.12	-0.56	-0.33	-0.06	-0.70	0.21

	Seed yield/m^2					No. of siliqua/ m^2					Seed yield/ha				
	P_2	P_3	P_4	P_5	P_6	P_2	P_3	P_4	P_5	P_6	P_2	P_3	P_4	P_5	P_6
T_{max}	0.85	0.57	0.14	-0.62	-0.52	0.92	0.60	0.14	-0.72	-0.60	0.83	0.53	0.12	-0.62	-0.49
T_{min}	0.76	0.08	-0.58	-0.81	-0.67	0.79	0.02	-0.67	-0.91	-0.76	0.73	0.03	-0.60	-0.81	-0.64
RH_m	-0.81	-0.60	-0.42	0.41	0.36	-0.89	-0.65	-0.41	0.46	0.43	-0.80	-0.61	-0.40	0.41	0.35
RH_e	-0.66	-0.78	-0.80	-0.67	-0.14	-0.72	-0.88	-0.87	-0.74	-0.12	-0.64	-0.78	-0.79	-0.66	-0.14
WS	-0.25	-0.01	-0.59	-0.81	-0.66	-0.30	-0.13	-0.66	-0.90	-0.72	-0.27	-0.03	-0.59	-0.80	-0.65
SS	0.69	0.49	0.26	0.08	-0.04	0.76	0.52	0.26	0.08	-0.02	0.68	0.47	0.23	0.10	-0.03
PE	0.85	0.67	-0.27	-0.72	-0.53	0.91	0.66	-0.33	-0.80	-0.62	0.83	0.63	-0.30	-0.71	-0.51
Rain	-0.61	-0.26	-0.29	-0.64	-0.04	-0.68	-0.29	-0.31	-0.71	-0.03	-0.69	-0.27	-0.28	-0.63	0.03

Critical Value (1-Tail, 0.05) = ± 0.24, Critical Value (2-Tail, 0.05) = ± 0.29, N = 48

3.2. *Effect of weather elements on biomass accumulation*

An increase in daytime temperature during vegetative phase produced increased biomass, but a significant slow down in gain of biomass was noted during maturity phase due to higher daytime temperature. The higher maximum temperature during grand growth period promoted plant growth (Fig.2). According to Chopra (1998) the role of air temperature during early growth stages of mustard crop is significantly important as it dominantly affects the rate of growth of biomass throughout the crop life. It has been an established fact that the temperature changes the duration of crop growth and consequently the crop was able to intercept incident radiation over an extended period, which ultimately got transformed into increased biomass. A decline in gain of biomass was recorded during maturity phase, before which a steep rise in growth rate was noticed during the siliqua and seed development phase. Chopra (1998) also reported similar results for *brassicas* at Delhi. An increase in minimum temperature during early vegetative phase (P_2) resulted in high plant biomass accumulation, however, an increase in minimum temperature during reproductive and maturity phases of crop resulted in decreased biomass accumulation (Fig.2). Since, weather parameters are interrelated, an increase in minimum temperature during latter phases of crop growth is usually accompanied by an increase in maximum temperature. Air temperature is the most important environmental factor, which influences the crop growth. Temperature determines the duration of various phenophases and consequently the time during which incident radiation can be intercepted and transformed to dry matter. The biomass accumulation in oilseed *brassicae* increased with increase in daily sunshine hours particularly during vegetative phase (Fig.2). Abundant radiant energy for an extended duration resulted in higher photosynthetic rate for longer period leading to an overall increase in biomass accumulation. The increase in wind speed decreased the biomass accumulation in *brassicas* (Fig. 2). In context of biomass production, the wind speed during vegetative phase was not that important but its role was significant during latter growth phases. The decrease in biomass accumulation during reproductive phase and at physiological maturity due to increase in wind speed could have been because of increased respiration rates resulting in lower biomass gains. During grand growth phase, the biomass accumulation in *brassica* increased with increase in evaporation rate. However, the increase in evaporation rates during physiological maturity resulted in its decline (Fig. 2). The increase in evaporation during early vegetative phase was because of higher daytime vapour pressure deficit developed due to increased ambient temperature, solar energy and low relative humidity. Optimum temperature and extended duration of sunshine during vegetative phase are congenial for oilseed *brassicae*. The increased rate of evaporation during physiological maturity because of higher air temperature and extended sunshine duration led to higher vapour pressure deficit causing loss of cell wall turgor which ultimately resulted in faster desiccation and reduced biomass accumulation.

3.3. *Effect of weather on yield and yield attributes*

The results of the correlation studies between weather parameters on one hand and the seed yield and its attributes on the other are presented in Table 1. It was noted that the maximum and minimum temperatures, pan evaporation and morning relative humidity played important role during vegetative phase of crop, when development of LAI took place. However, during reproductive and maturity phases, in addition to maximum and minimum temperatures, the wind speed and pan evaporation also showed relationship with the seed yield and its attributes in oilseed *brassicae*. Kar *et al.* (!998) have revealed that the seed filling stage is the most vital stage for radiation interception for photosynthesis and biomass partitioning towards pods. The rainfall during the crop growing season occurring during various phenophases either have no association or had a negative relationship with seed yield and the attributes. This negative association of rainfall could have been because of the presence of abundant soil moisture in the soil profile. The significant positive association of maximum and minimum temperature during vegetative phase indicated that temperatures prevailed during vegetative phase were within the cardinal limits of temperatures required by the crop. Hence, the higher temperatures during vegetative phase resulted in higher photosynthetic activity leading to better plant growth and development, which ultimately got translated, into higher seed yield because of favourable yield attributes. According to Chopra (1998), the role of air temperature during early vegetative phase of crop is significantly important as it dominantly affects the rate of growth of biomass throughout the crop life and hence the seed yield. The significant negative relationship between minimum and maximum temperature during reproductive phase with seed yield and the attributes indicated that the minimum temperature and maximum temperature in a day are highly dependent on each other. Therefore, occurrence of higher maximum temperature will lead to increased respiration resulting in poor development of yield attributes. The significant positive association of pan evaporation at vegetative phase was because of positive significant association of sunshine hours and minimum and maximum temperatures. The sunshine duration was better correlated with seed yield and attributes at vegetative than at reproductive phase. Bishnoi *et al.* (1991) had reported similar results in mustard crop.

4. Conclusions

Increase in maximum temperature and sunshine duration during the grand growth period resulted in marked increase in LAI and biomass accumulation in mustard crop. This improvement in growth parameters was further instrumental in bringing about considerable increase in seed yield.

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