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Short Communication

Microclimate and thermal indices of garden pea (*Pisum sativum* L.) under poplar (*Populus deltoides* Bartr.) based agroforestry system

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Agroforestry is a practically feasible, scientifically and ecologically sound system that has emerged as a viable land use system for crop diversification and a way to achieve the target of bringing 33.3% of the total area under forest as against 24.6% of the current area for maintaining ecological balance (Anonymous, 2021). It also provides a buffer against the whims of climate by improving microclimate and revitalizing agro-ecosystem with enhanced stability and resilience. In an agroforestry system, the integration of trees along with crops modifies the microclimate, which influence various physiological processes of undergrown crops and ultimately their production potential. More specifically, the shade of the trees in tree-crop combination affects the yield of crops significantly. Photosynthesis is a major physiological process that gets affected most; a decrease in net photosynthesis rate, transpiration, and stomatal conductance of crops has been reported under poplar as compared with sole crops by Chauhan *et al.* (2013). Poplar, being a deciduous tree, sheds all its leaves during winter the months, due to which large number of crops can be intercropped along with it and also its short harvestable life cycle of 5-6 years, multi-utility wood, and ease in marketing made it one of the most adopted tree species for agroforestry throughout the north-western region of India.

Garden pea, which has been recognized as the queen of pulses, is an annual herbaceous plant of the family Fabaceae. It is a cool season crop and requires 18-22 ^{o}C temperature for optimum germination and growth. Temperature plays a crucial role in determining crop growth rate and productivity. Modification in climatic factors viz. temperature, relative humidity and photosynthetic active radiation (PAR) has been recorded beneath the poplar canopy as compared with open field conditions (Singh *et al.,* 2019; Bhardwaj *et al*., 2021). Thus, the present study was conducted to analyze the microclimate modifications along with the computation of agroclimatic indices for different garden pea varieties cultivated under poplar block plantation.

The current investigation was conducted at the main experimental area of the Department of Forestry and Natural Resources, Punjab Agricultural University, Ludhiana, during the *rabi* season 2021-22. Ludhiana falls in the central agro-climatic zone of Punjab; situated at 30º 58' N latitude and 75º 45' E longitude and about 247 meters above the mean sea level. The experiment was laid out in split plot design with two cropping systems (Poplar + garden pea and garden pea sole) and three dates of sowing (1st October, 15th October and 1st November) in the main plot and four garden pea varieties (AP-3, Matar Ageta-7, Punjab 89, and Mithi Phali) in the sub-plot, with three replications. The poplar plantation aged six years was established at 8 m × 2.5 m spacing with north-south row orientation. Weekly and monthly mean temperature and relative humidity (RH) were computed from the daily recorded data for both poplar and sole field conditions. Throughout the crop growth period, data for PAR was recorded at 15 days interval between 12:00 – 2:00 pm on clear sunny days using a help of line quantum sensor. For the computation of PAR interception (%), the incoming and outgoing radiations on top of the crop canopy and transmitted radiations at the ground surface below the crop canopy were measured:

$$\text{PAR interception (\%)} = \frac{\text{IPAR} - (\text{RPAR} + \text{TPAR})}{\text{IPAR}} \times 100$$

Where, IPAR = Incident solar radiation (W m^{-2}), RPAR = Reflected solar radiations (W m^{-2}), and TPAR = Transmitted solar radiation (W m^{-2})

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Table 1: Accumulated heat units and RUE of garden pea sown at different dates under poplar and as sole crop

Treatment	GDD (°C day)	HTU (°C day hrs)	PTU (°C day hrs)	HUE (kg/ha^{-1} °C day^{-1})	RUE (q MJ^{-1})
Cropping system					
Poplar + garden pea	985	5869	10400	4.6	1.5
Sole garden pea	1056	6293	11163	8.2	2.2
CD (p=0.05)	71	263	599	0.3	0.1
Date of sowing					
1st October	1251	8556	13462	5.0	1.7
15th October	1002	5875	10563	6.2	1.8
1st November	809	3813	8321	8.1	1.8
CD (p=0.05)	87	322	733	0.4	NS
Varieties					
AP-3	961	5913	10191	4.7	1.5
Matar Ageta-7	935	5812	9903	5.3	1.6
Punjab 89	1119	6365	11762	8.3	2.2
Mithi Phali	1068	6237	11273	7.5	1.9
CD (p=0.05)	68	299	683	0.3	0.2

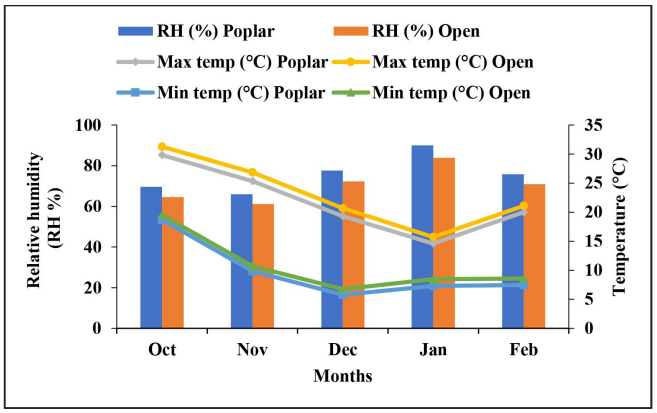

Fig. 1: Monthly variation in temperature and RH under poplar and open field conditions during the growing season of garden pea

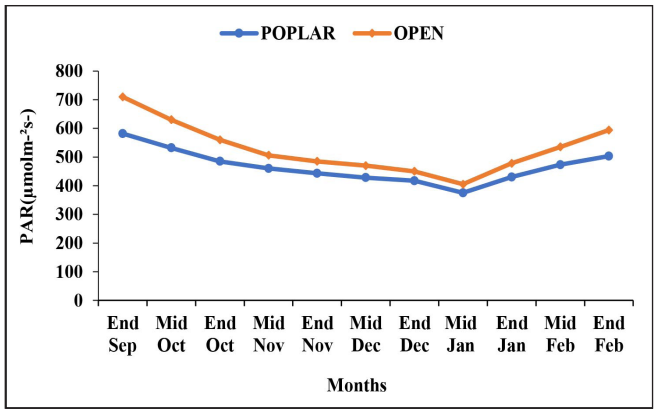

Fig. 2: Monthly variation of PAR (µmolm^{-2}s^{-1}) under poplar and open field condition during the growing season of garden pea

Agroclimatic indices

The agroclimatic indices viz., accumulated growing degree days (GDD), accumulated photothermal units (PTU), accumulated heliothermal units (HTU) and heat use efficiency (HUE) were calculated as per the standard formulae (Gill *et al.*, 2014). Radiation use efficiency (RUE) was determined from the yield obtained per unit of photo synthetically active radiation (PAR) intercepted by the crop canopy.

Variation in temperature and PAR

The maximum and minimum temperature were recorded low beneath the poplar canopy than sole field. The maximum and minimum temperature ranged from 15.7 - 31.3 °C and 6.8 - 19.5 °C in sole field which reduced by 1.1 - 1.5 °C and 0.8 - 1.0 °C, respectively beneath the poplar canopy (Fig. 1). Relative humidity showed a reversal of temperature trend, its value was higher by 4.8 - 6.1% under poplar as compared with the open field conditions. The value of PAR was ranged from 405 - 710 µmolm^{-2}s^{-1} in open field, while under poplar, its value reduced to 375-582 µmolm^{-2}s^{-1} (Fig. 2). The difference in PAR between beneath, the poplar canopy and open field was the highest during the end-September (128 µmolm^{-2}s^{-1}), while it became minimum during mid-January (30 µmolm^{-2}s^{-1}) due to the complete leaflessness in poplar. Reduced PAR under poplar plantation has become one of the most limiting factors resulting reduction in the yield of under grown crops (Virk *et al.,* 2017; Jyoti *et al.,* 2019).

Thermal indices

GDD is a temperature-based indicator that helps in estimating the time of occurrence of the particular phenological stage of a crop. Garden pea sown as sole accumulated more GDD as compared with crop sown under poplar plantation. This can be attributed to the higher air temperature in sole field conditions, whereas air temperature was low beneath the poplar canopy (Table 1). Likewise, Gill *et al.,* (2016) and Kaur *et al.,* (2020) also recorded lower GDD accumulation by wheat sown beneath the poplar as compared with sole sown crop. Among all the varieties, Punjab

89 accumulated the highest GDD (1119 °C day) due to longer crop duration as compared with other varieties. Similar trend was also recorded for HTU and PTU i.e. accumulated more by sole crop as compared with the crop sown under poplar. PTU and HTU accumulated by Punjab-89 was 11163 and 6293 °C day hrs in sole crop conditions, which reduced to 10400 and 5869 °C day hrs, respectively under poplar plantation (Table 1).

The estimation of HUE is helpful for determining a crop's production potential in various environments as it depicts the heat utilized by crop to produce one unit of plant biomass. HUE reduced under poplar as compared with sole conditions due to reduction in yield of crop under shade. The highest HUE was recorded in 1st November (8.1 kg) sown crop due to better crop growth and yield in comparison with other dates of sowing (Table 1). RUE signifies the ability of crops to capture solar energy and transform it into biomass or grain yield (Hatfield, 2014). RUE of garden pea decreased under poplar compared to sole crop due to lower yield under poplar plantation. However, the effect of date of sowing remained non-significant on RUE of crop. Among all the varieties, Punjab 89 recorded the maximum RUE (2.2) followed by Mithi Phali (1.9) (Table 1).

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