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Research Article

Comparison of Micrometeorological Parameters in Wheat Crop under Open and Poplar Plantation

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Abstract

The present study was conducted at the Research Farms, Department of Climate Change and Agricultural Meteorology and Department of Forestry and Natural Resources, Punjab Agricultural University, Ludhiana, during the *rabi* season of 2021-22. The experiments were conducted under split plot design with 3 replications having three dates of sowing (20th October, 5th November and 20th November) and 2 disease inoculation levels (Inoculated and un-inoculated) in main plots with three varieties (HD 2967, PBW 725 and HD 3087) in sub plots. The experiments were conducted under open conditions and under poplar plantation. The micrometeorological parameters like photosynthetically active radiation (PAR), canopy temperature and relative humidity within crop were observed at periodic intervals under both growing environments. Among micrometeorological parameters, Incident PAR (1280 Watt/m^2 in open and 910 Watt/ m^2 under poplar plantation) and temperature inside the canopy (25.8°C in open and 24.6°C under poplar plantation) was maximum in 20th November sowing. While, relative humidity (56.3% in open and 59.0 % under poplar plantation) was maximum in 20th October sown crop. The grain yield was maximum (38.3 q/ha) in 20th October sowing followed by 5th November (37.0 q/ha) and 20th November (33.5 q/ha) sown crop under open conditions. Whereas, under poplar plantation, grain yield was comparatively lesser than open conditions.The grain yield was maximum (27.6 q/ha) in 20th October sowing followed by 5th November (26.0 q/ha) and 20th November (21.4 q/ha) sown crop under poplar plantation. Among different varieties, PBW 725 gave higher grain yield under open and poplar plantation conditions.

Key Words: Micrometeorological parameters, Open condition, Poplar plantation, Grain Yield, Wheat

1. Introduction

India's agricultural industry accounts for 20 per cent of the country's GDP and ranks second in the world. Rice, wheat, maize, barley, oats, rye and sorghum are some of the most commonly farmed cereal crops in the country, with wheat playing a significant role in the daily diet. Wheat is one of the most important cereal crop for majority of the world's population. It belongs to the genus *Triticum* of the Poaceae family and positions first among the cereals both in regard of production and productivity. It is considered as the significant stable food of about two billion people of world population and provides nearly 55 per cent of the carbohydrates and 20 per cent of the food calories consumed internationally. Wheat is the most common *rabi* cereal crop and it is grown primarily in India's north-western regions. In India, it covers approximately 31.1 million hectares and produces 106.2

million tonnes. During 2020-21, the area under wheat in Punjab was estimated to be around 35.30 lakh hectares with a production of 171.85 lakh tonnes (Anonymous 2022).

Wheat can be grown on an extensive latitude of climatic conditions and in Indian conditions, it is mostly grown between 10°N to 37° N latitude and from ocean level to an elevation of 3300 m (Fieldman 2001). Weather elements greatly affect the production and productivity of wheat crop and yield of wheat crop in India is considered to be reduced due to short-term temperature extremes (Lobell *et al* 2012). Wheat is a long day plant and requires photoperiod of about 14-18 hours. To protect the crop from the unfavourable environmental conditions, the range of optimum temperature for germination of wheat seed is from 3.5-35°C. The ideal temperature for tillering and grain formation is 16-22°C and 23-25°C, respectively. During vegetative phase of crop, if the temperature goes above 25°C, there would be significant reduction in yield (Pandey and Sinha 2006). Region having precipitation shifts from 25 to 150 cm is appropriate for wheat development. Under rainfed conditions, 15-20 cm all around circulated precipitation is reasonable during winter. Changes in weather during the growth season, particularly during the reproductive stage have an impact on wheat yield.

Wheat is widely produced in central and northern India as part of an agroforestry system. Poplar makes a better companion tree than other tree interfaces because it sheds its leaves before sowing of wheat in the winter season, and higher wheat yields have been recorded under poplar in agroforestry systems compared to other tree–crop combinations. The inherent potential of wheat under poplar-based intercropping system can be achieved by enhancing the competitive ability of wheat through appropriate and sustainable land use system. With these considerations in mind, the purpose of this study was to compare micrometeorological parameters in wheat in sole cropping and poplar based agroforestry system.

2. Materials and Methods

2.1 Study Site

The present study was conducted at the Research Farms of Department of Climate Change and Agricultural Meteorology and Department of Forestry and Natural Resources, Punjab Agricultural University, Ludhiana, during the *rabi* season of 2021-22. The latitude, longitude, and elevation of Ludhiana are 30°54'N, 75°48'E, and 247 m, respectively. Climatic condition of Ludhiana is subtropical and semi- arid, with cold winters and warm summers. Summer, monsoon, and winter are the three distinct seasons. Maximum temperature above 40°C is common in May and June, but very cold evenings are prevalent in December and January. During the winter, temperature may fall below 0°C. The annual average rainfall is 760 mm. Out of total annual rainfall approximately 80 per cent is received during June-September.

2.2 Experimental Details

The two field experiments were conducted simultaneously one in the open conditions at field of Research farm of Department of Climate Change & Agricultural Meteorology and second experiment was conducted under poplar plantation at the research farm of Department of Forestry and Natural Resources, PAU, Ludhiana during the *rabi* season of 2021-22. The experiments were conducted under split plot design with 3 replications having three dates of sowing (20th October, 5th November and 20th November) and 2 Karnal bunt disease inoculation levels (Inoculated and un-inoculated) in main plots with three varieties (HD 2967, PBW 725 and HD 3087) in sub plots. The block plantation consists of six years old poplar trees of clone L-48, spaced at 8 x 2.5 m.

2.3 Micrometeorological observations

At 15 days interval starting from 45 days after sowing, photosynthetically active radiations (PAR) incident on the crop under open and poplar plantation wheat were measure dusing a Line Quantum Sensor (Model LI-190 SB). Relative humidity within the crop canopy was recorded using a psychron at 15 days interval. With the help of an infrared thermometer (FLUKE-574), canopy temperature was measured at 1430 hours at 15-day intervals from 45 to 135 days after sowing (DAS). While taking canopy temperature data, 45^{o} angle was maintained between the infrared thermometer and the canopy, following the Stefan-Boltzmann's law.

2.4 Yield and yield attributing characteristics

Yield and yield attributing characteristics viz., number of effective tillers, number of grains per ear, 1000-grain

weight, biological yield and grain yield were recorded at the time of harvesting of crop. Data related to grain yield and yield attributes were statistically analysed using CPCS-I.

3. Results and Discussion

The key factors affecting the microclimate of a field includes the photosynthetically active radiation interception, relative humidity inside the canopy and canopy temperature that were recorded at the different phenological stages of wheat crop in open condition and under poplar plantation. The incident PAR was recorded more in case of open condition as compared to that of poplar plantation throughout the growing season. The reason behind the lesser incoming PAR under poplar plantation was the canopy cover of poplar that hinders the incident of radiation. Relative humidity inside the canopy under poplar plantation was remained higher as compared to open field condition throughout the crop duration due to lower temperature under poplar plantation compared to open condition. The canopy temperature under open condition for wheat was higher compared to poplar planted wheat.

3.1 Photosynthetically active radiation

Photosynthetically active radiation designates the spectral range of solar radiation from 400 to 700 nanometers that plant is able to use in the process of photosynthesis. The percentage of PAR interception is directly proportional to the total incident radiation coming from the sun. The total incident radiation over a crop cover plays a significant role in the proportion of PAR interception. The value of the incident radiation varied along with the different phenological stages and different dates of sowing.

Among different dates of sowing the range of incident PAR in open condition was 843-1200 watt/m^2 and under poplar plantation it was 770 to 1050 watt/m^2 on 20th October sown crop and it was 841-1323 watt/m^2 in open condition and 771-1212 watt/m^2 under poplar plantation in case of 5th November sowing of wheat crop. Similarly, total incident radiation varied from 860-1580 watt/m^2 in open condition and 790-1360 watt/m^2 under poplar plantation when wheat was sown on 20th November as presented in Figures 1, 2 and 3.

The trend of variation of total incident radiation under both growing conditions was similar and it varied with growth of the wheat crop and canopy cover of poplar plantation. The total incident radiation showed decline from 45th day after sowing to 90th day after sowing and after that it continued to increase till harvesting in case of 20th October and 5th November sown wheat crop. For 20th November sowing, the total incident radiation continued to increase till harvesting from 45th day after sowing in open condition and under poplar plantation. It can be concluded that total incident radiation throughout the growing period remained higher in case of open condition as compared to poplar plantation.

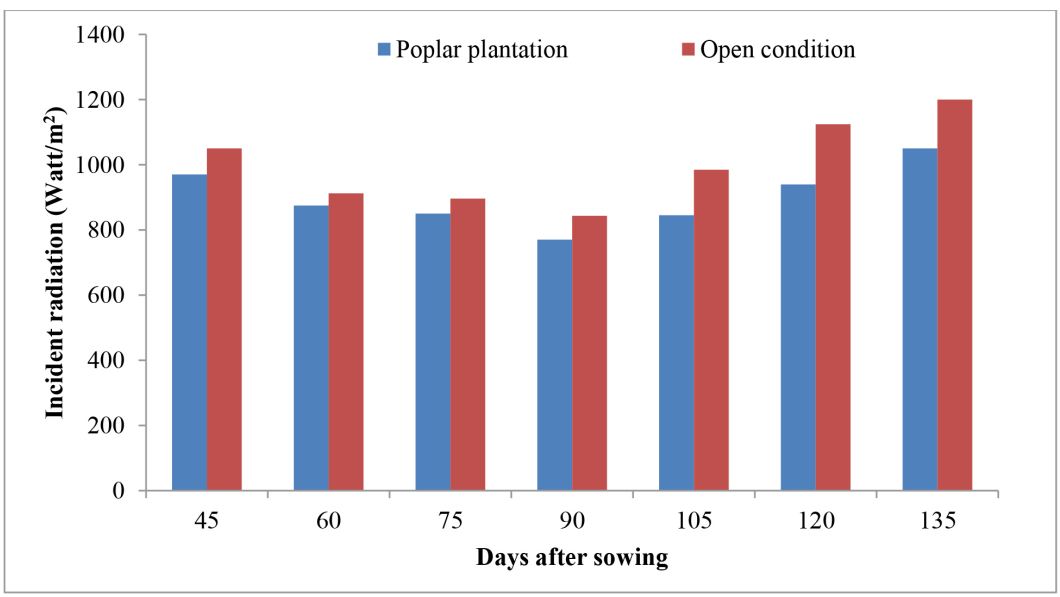

Fig. 1: Comparison of incident radiation in open and poplar plantation in 20th October sowing

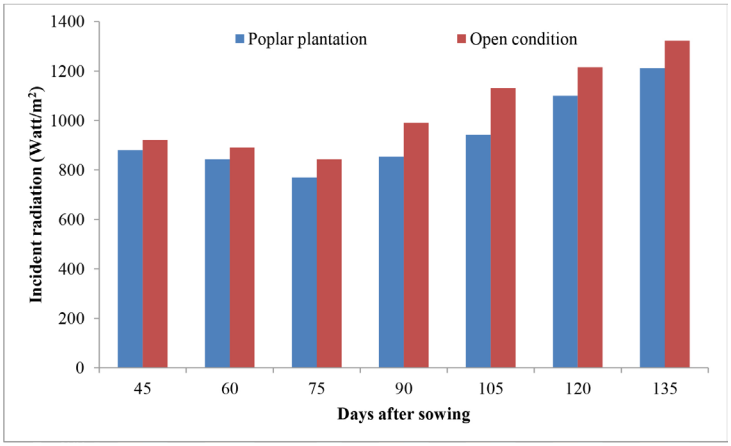

Fig. 2 Comparison of incident radiation in open and poplar plantation in 5th November sowing

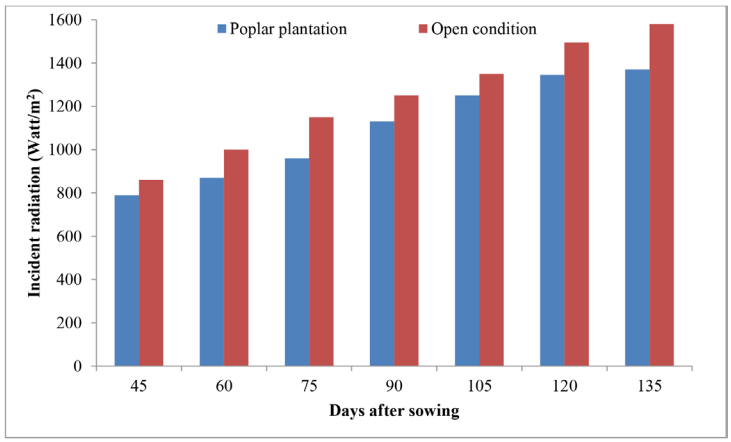

Fig. 3: Comparison of incident radiation in open and poplar plantation in 5th November sowing

Table 1: Yield and yield attributing characteristics of wheat varieties in different treatments under open condition

Treatments	Effective tillers perm row length (no.)	Grains perear (no.)	1000-grains weight (g)	Biological yield (q/ha)	Grain yield (q/ha)
Date of sowing					
20thOctober	182.0	41.8	39.7	122.0	38.3
5thNovember	168.0	40.0	39.4	118.0	37.0
20thNovember	155.4	38.7	35.4	102.1	33.5
Disease inoculation level					
Inoculated	165.5	39.8	37.2	111.0	35.8
Un-inoculated	171.4	40.5	39.2	117.0	36.8
CD (p=0.05)	3.2	1.9	0.7	3.8	0.8
Varieties					
HD 2967	168.4	39.8	38.0	113.9	35.8
PBW725	169.0	41.0	38.9	116.6	36.8
HD 3086	167.3	39.7	38.1	114.8	36.2
CD(p=0.05)	NS	NS	0.5	3.1	0.6

3.2 Canopy temperature and relative humidity within canopy

The relative humidity within the crop and canopy temperature play an important role in crop growth and development. Canopy temperature and relative humidity inside the canopy were recorded at periodic interval after 45 days of sowing under both the growing conditions. Canopy temperature was recorded at 1430 hours at different phenological stages and it was higher in 20th November sown crop followed by 5th November and 20th October sown crop and it was highest at 135 days after sowing and lowest at 45 days after sowing both in case of open condition and poplar plantation. On 20th October sown wheat canopy temperature was 22.4°C and 20.9°C, for 5th November sowing, it was 24.5 °C and 22.6 °C and for 20th November sowing, it was 25.8°C and 24.5°C in open condition and poplar plantation, respectively. At 45 days after sowing, it was 18.3°C, 19.8°C and 22.1°C on 20th October, 5th November and 20th November sown crop, respectively in open condition and 17.2 °C, 17.9°C and 21.0°C in 20th October, 5th November and 20thNovember sown crop, respectively under poplar plantation. At 135 days after sowing, canopy temperature was 27.1°C, 28.2°C and 30.0°C in 20th October, 5th November and 20th November sown crop, respectively, in open condition and 25.9°C, 26.9°C and 27.8°C in 20th October, 5th November and 20th November sown crop, respectively in poplar plantation. From these observations, it can be concluded that canopy temperature in open condition remained higher by approximately 3°C throughout the growing season as compared to poplar plantation due to canopy cover of poplar plantation that resulted in cooler condition as compared to open condition as shown in Figures 4, 5 and 6.

The relative humidity inside the crop canopy was highest (56.3%) in 20th October, followed by 5th November (52.4%) and 20th November (48.6%) sown wheat under open condition and similar trend was observed under poplar plantation with higher humidity in 20th October (59.0%), followed by 5th November (54.9%) and 20th November (51.2%) sown wheat. Maximum (75% & 78.5%) relative humidity inside the canopy was recorded at 90 days after sowing under open and poplar plantation, respectively and minimum (66% & 69%) was recorded at 135 days after sowing, under open and poplar plantation, respectively on 20th October sowing. For 5th November sowing, maximum relative humidity inside the canopy (75% & 77%) was recorded at 75 days after sowing, under open and poplar plantation, respectively and minimum (64 % & 66%) was recorded at 135 days after sowing, under open and poplar plantation, respectively. Similarly, in case of 20th November sowing, maximum relative humidity inside the canopy (74% & 75%) was recorded at 60 days after sowing, under open and poplar plantation, respectively and minimum (60% & 63%) was recorded at 135 days after sowing, under open and poplar plantation, respectively. This indicates that relative humidity inside the crop canopy remained higher under poplar plantation due to lower temperature as compared to that of open condition.

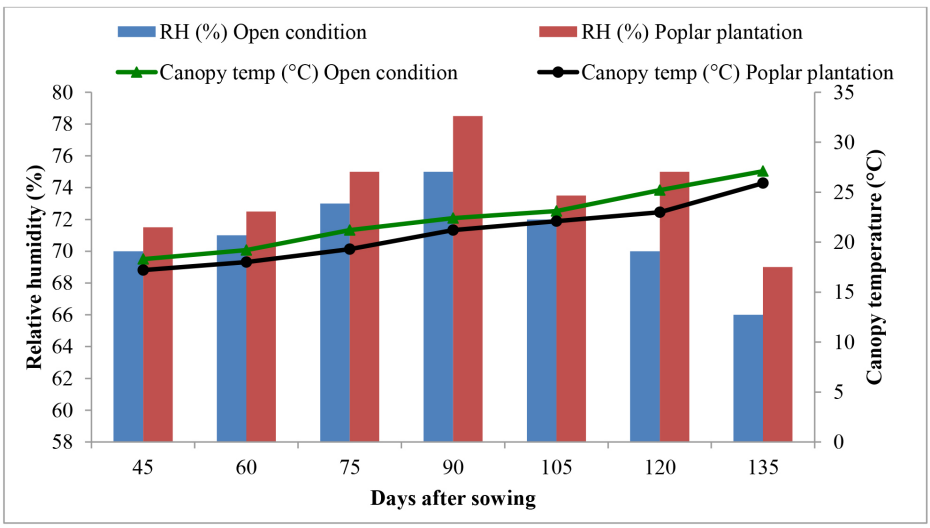

Fig. 4: Comparison of canopy temperature and relative humidity under 20th October sowing

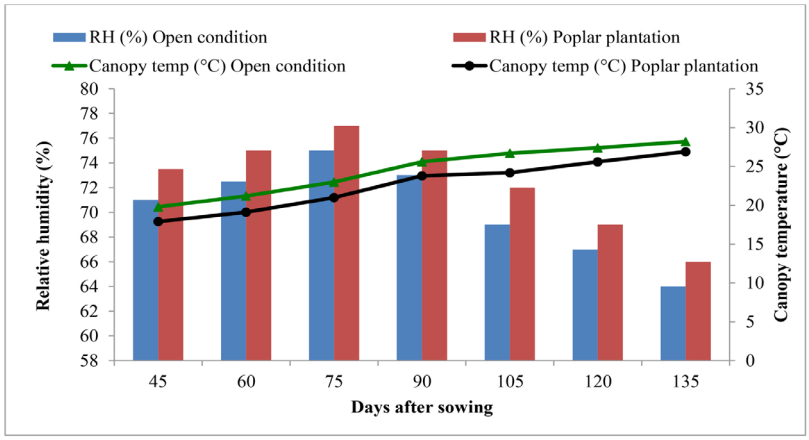

Fig. 5: Comparison of canopy temperature and relative humidity under 5th November sowing

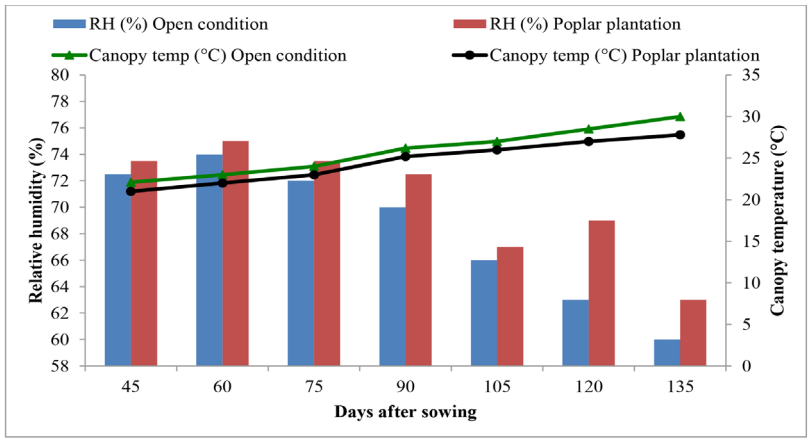

Fig. 6: Comparison of canopy temperature and relative humidity under 20th November sowing

3.3 Yield and yield attributing characteristics

The data related to yield attributing characteristics of wheat under different treatments is presented in Table 2. The number of effective tillers varied significantly depending on the date of sowing. The crop sown on 20th October had a higher number of effective tillers, when compared to the other two dates of sowing. The number of effective tillers was 182.0 in 20th October, followed by 168.0 in 5th November and 155.4 in 20th November sown crop.

The number of effective tillers decreased significantly with delay in sowing. Number of grains per ear was significantly higher in 20th October sown crop followed by 5th November and 20th November sown crops. The 1000-grain weight was found to be significantly higher in the first date of sowing compared to the third date of sowing and was at par with second date of sowing. In 20th October, 5th November and 20th November sown crops, 1000-grain weight was 39.7 g, 39.4 g and 35.4 g, respectively.

Table 2: Yield and yield attributing characteristics of wheat varieties in different treatments under poplar plantation

Treatments	Effectivetillers permrow length (no.)	Grains perear (no.)	1000-grains weight (g)	Biological yield (q/ha)	Grain yield (q/ha)
		Date of sowing			
20thOctober	125.4	34.1	35.8	96.2	27.6
5thNovember	115.0	33.0	34.0	94.0	26.0
20thNovember	103.2	30.1	30.2	79.0	21.4

Disease inoculation level					
Inoculated	114.0	32.0	31.6	82.6	23.2
Un-inoculated	115.0	32.8	34.9	93.2	26.7
CD(p=0.05)	0.7	1.4	0.9	3.7	1.8
Varieties					
HD 2967	115.3	31.7	33.2	86.9	24.8
PBW725	116.1	32.8	33.9	91.7	26.2
HD 3086	113.0	32.3	32.8	86.6	23.9
CD(p=0.05)	0.5	NS	0.8	3.1	1.5

Buttar*et al* (2018) reported a higher number of effective tillers during early sowing (30th October) and significantly lower effective tillers during late sowing (15th and 30th November). They also reported that 1000-grain weight was higher under normal sowing conditions (30th October) and decreased with delayed sowing. Wahid (2017) also reported a significant decrease in 1000-grain weight with delayed wheat sowing. Alam*et al* (2013) found that delay in sowing reduced the number of effective tillers, grains per ear, and 1000-grain weight. They further explained that the decrease in 1000-grain weight with delayed sowing was due to a shorter growth period and shrivelling of grain due to high temperature during the milk and grain filling stages. The difference among different yield attributing characteristics was found to be non-significant under different varieties and disease inoculation levels under open condition. Among inoculation levels, different parameters viz., higher number of effective tillers and 1000 grain weight were significantly higher in un-inoculated conditions as compared to inoculated conditions. Among varieties, PBW 725 gave significantly higher 1000 grain weight than HD 2967 and HD 3086 but effective tillers and number of grains per ear were non-significant among three varieties.

Biological yield, grain yield and straw yield obtained under different treatments are presented in Table 3. The data showed that 20th October and 5th November date of sowing had a non-significant impact on biological yield, seed yield and straw yield, while 20th November date of sowing had a significant impact on these parameters when compared with first two date of sowing. Early sowing resulted in the higher biological yield, seed yield and straw yield, and late sowing resulted in the lowest. The biological, seed and straw yields were 122.0, 38.3 and 83.7 q/ha in 20th October sown wheat, respectively. They were 118.0, 37.0 and 81.0 q/ha in 5th November and 102.1, 33.5 and 68.6 q/ha in 20th November sown crop.

According to Ram *et al* (2012), early sowing has a positive effect on grain yield. Grain yield increased with early sowing and decreased significantly with delayed sowing due to higher yield attributes and growing degree days. Heat had a negative effect on grain yield at later stages of crop development and earing in delayed sowing. The difference among biological yield, seed yield and straw yield was found to be non-significant under different varieties and disease inoculation levels under open condition. Among inoculation levels, grain yield was significantly higher (36.8 q/ha) under un-inoculated level as compared to inoculated level, where it was 35.8 q/ha. Among different varieties, grain yield was significantly higher of PBW 725 (36.8q/ha) than HD 2967 and HD 3086.

The number of effective tillers per meter row length, number of grains per ear and 1000-grains weight varied significantly depending on the date of sowing under poplar plantation (Table 4).

The crop sown on 20th October had a higher number of effective tillers, number of grains per ear and 1000 grains weight when compared to the other two date of sowing. The number of effective tillers was significantly higher (125.4) in 20th October, followed by 5th November (115.0) and 20th November (103.2) sown crop. The number of effective tillers decreased significantly as sowing was delayed. The highest 1000-grain weight was recorded non-significant in the 20th October (35.8) with 5th November (34.0) sowing and showed significant results with 20th November (30.2) sowing as compared to first two dates of sowing. Similarly, highest number of grains per ear was recorded in 20th October (34.1), followed by the 5th November (33.0) and the lowest in the 20th November (30.1) sown wheat. The number of grains per ear decreased significantly in third date of sowing as compared to other two dates of sowing. Among inoculation levels, number

of effective tillers per meter row length was significantly higher (115.0) under un-inoculated level as compared to inoculated level, where it was 114.0. Number of grains per ear was statistically at par in inoculated and un-inoculated levels. 1000 grain weight was significantly higher under un-inoculated conditions than inoculated conditions. Among different varieties, PBW 725 showed more number of effective tillers, grains per ear and 1000 grain weight under poplar plantation.

Biological yield, grain yield and straw yield obtained under different treatments are presented in Table 5. Early sowing resulted in the higher biological yield, seed yield and straw yield and late sowing resulted in the lowest. The biological, seed and straw yields were 96.2, 27.6, and 68.6 q/ha in 20th October sown crop, respectively. They were 94.4, 26.9 and 67.5 q/ha in 5th November and 78.9, 21.3 and 57.6 q/ha in 20th November sown crop. The difference among biological yield and straw yieldwas found to be non-significant under different varieties and the seed yield was significantly higher in PBW 725 (26.2q/ha) than HD 2967 (24.8q/ha) and HD 3086 (23.9q/ha) under poplar plantation. For different disease inoculation levels, biological yield, grain yield and straw yield found to be significantly higher under un-inoculated compared to inoculated condition. They were 93.2, 26.7 and 66.5 q/ha under un-inoculated and 82.6, 23.2 and 59.4 q/ha under inoculated condition.

Conclusion

It was recorded that incident PAR remained higher in case of open condition as compared to poplar plantation throughout the growing period. Canopy temperature in open condition remained higher up to 3°C throughout the growing season as compared to poplar plantation due to canopy cover of poplar plantation resulted in cooler condition as compared to open condition and that relative humidity inside the crop canopy remained higher under poplar plantation due to lower temperature as compared to that of open condition. Yield and yield attributing characters remained higher in open condition as compared to wheat grown under poplar plantation due difference in microclimate of both growing conditions.

Author contributions

Conceptualization of experimentation (BS, SKS & NK); Designing of the experiments (BS, SKS & NK); Experimental materials (BS, SKS & NK); Execution of field experiments and data collection (BS, SKS & NK); Analysis of data and interpretation (BS, SKS & NK); Preparation of the manuscript (all authors).

Conflict of interest

The authors declare no conflict of interest.

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