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Microclimate: Diurnal Temperature Variation inside Crop Canopy of Pearl Millet under Different Sowing Environments

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The microclimate was evaluated for the pearl millet [*Pennisetum glaucum* (L.) R. Br.] crop at different height inside the crop canopy. Field experiments were conducted during autumn seasons and temperature was measured at bottom, middle and top of the crop canopy at panicle initiation stage, boot stage, 50 per cent flowering, dough stage and physiological maturity stages from 09:00 in the morning to 05:00 in the evening. The temperature profiles indicates that lower temperature were recorded at the top of crop canopy as compare to bottom of crop canopy *i.e.* temperature inside the crop canopy was higher than at top of the crop canopy in all the treatments. Temperature profiles showed decreasing trend in temperature inside the crop canopy means temperature

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decrease with increase in height inside the crop canopy in all the treatments within the crop canopy in both the crop seasons. The maximum temperature was observed in afternoon hours and the minimum temperature was recorded in the morning hours.

Keywords: Pearl millet; canopy; temperature; growth stages.

1. INTRODUCTION

Under hot dry conditions on infertile soils of low water holding ability where other cereal crops usually fail totally there, pearl millet [*Pennisetum glaucum* (L.) R. Br.] is grown as subsistence crop largely for its ability to produce grain in harsh conditions [1]. In pearl millet temperature requirements for growth and development depends on the varieties. Temperature ranges from 22 to 35ºC in optimum for growth of plant and among pearl millet genotypes averaging 34ºC is required for germination with upper limit lies between 47 and 52ºC and base temperature lies between 8 and 13.5ºC [2]. Temperature ranges from 31 to 35ºC is optimum for a virtuous photosynthetic response. High temperature accelerates the production rate of the leaves [3]. Yield and how tall a plant will grow could be affected by the sowing time. Most important and non-monetary input that affect the yield of the crop is sowing time and also considered as a critical input for higher yield. Optimum planting time results in healthy and vigorous plants while delay in sowing time results in reduction in plant height and yield [4]. Sowing at optimum time improves the productivity by providing suitable environment at all growth stages. Crop sown on proper date of sowing enjoy favorable climatic conditions in term of temperature and other climatic parameters during various crop growth stages which reflected into better growth and yield [5].

For choosing the proper sowing time various factors like agro-climatic conditions crop growing season in considerations, so that the crop could receive proper temperature and photoperiod during its different pheno-phases which is required by the crop for proper growth and better yield. Keeping the above facts in view, the present study on diurnal temperature variation inside crop canopy of Pearl millet was carried out to find the date of sowing which experience the favorable weather conditions.

2. MATERIALS AND METHODS

2.1 Location of Experiment Site

The field experiments were conducted at research farm of Department of Agricultural Meteorology, CCS HAU, Hisar, Haryana (India) in the autumn seasons of 2018 and 2019, located at latitude 29º10' N, longitude 75º46' E and altitude of 215.2 m a.s.l.

2.2 Climatic Conditions of Experimental Site

The climate condition of Hisar over most of the year is of an obvious continental character. In summer, climatic condition is very hot and markedly cold in winter. The maximum temperature lies above 45 ºC usually during summer, in winter, the minimum temperature below or near freezing point. The rainfall in the region is low and erratic, south-westerly wind prevailed during monsoon season brings rain. In monsoon period lasting from the middle of June to the end of September on which autumn and spring crops sowing depends on and the other is the winter rains which occur from December to February, benefiting *Rabi* crop. Rainfall is meagre in Hisar.

2.3 Experimental Design

The experiment was put in a split plot design and comprised of three date of sowings (main plot treatments) *viz*. D_1- 2nd fortnight of June, D_2- 1st fortnight of July, D_3- 2nd fortnight of July and four sub plot treatments comprising four varieties *viz*. V_1- HHB 67 Improved, V_2-HHB 197, V_3-HHB 272 and V_4-HHB 299 with three replications (random fields with net plot size: 4.5 × 5.0 m, number of plots: 36).

2.4 Micrometeorological Observations

Micro-meteorological (temperature) observations was recorded in the experimental location during panicle initiation stage, boot stage, 50 per cent flowering, dough stage and physiological maturity stages at the time of clear sky at one hourly interval stating from 09:00 in the morning to 05:00 in the evening.

The temperature was measured at bottom, middle and top of the crop with the help of digital Psychrometer then temperature profiles were drawn.

3. RESULTS AND DISCUSSION

3.1 Temperature Profile

The temperature profiles shown in Figs. 1 to 10 indicate that lower temperature was recorded at the top of crop canopy as compare to bottom of crop canopy *i.e.* temperature inside the crop canopy was higher than at top of the crop canopy in all the treatments. Temperature profiles were lapse in all the treatments within the crop canopy. The maximum temperature was observed in afternoon hours and the minimum was in the morning.

At panicle initiation stage in crop season 2018 as depicted in Fig. 1, maximum temperature (41.7 ºC) was recorded at the bottom of the crop canopy in the afternoon (02:00) with D_1 and minimum temperature (26.0 ºC) was recorded at top of the crop canopy at 9 in the morning in D_3. While during crop season 2019 as depicted in Fig. 6, maximum temperature (42.6 ºC) was recorded at the bottom of the crop canopy at 02:00 in the afternoon with D_3 and minimum temperature (24.6 ºC) was recorded at top of the crop canopy at 09:00 in the morning in D_2. Among pearl millet hybrids, maximum temperature was recorded with V_4 in both the crop season at the bottom of the crop canopy at 02:00 in the afternoon (43.0 and 44.5 ºC) in crop seasons 2018 and 2019, respectively. In both the crop seasons 2018 and 2019, Minimum temperature was recorded in V_1 at the bottom of the crop canopy at 09:00 and 10:00 in the morning with 25.5 ºC and 25.2 ºC in crop seasons 2018 and 2019, respectively.

At booting stage in both the crop seasons 2018 and 2019 as depicted in Figs. 2 and 7, maximum temperature was recorded at the bottom of the crop canopy at 02:00 in the afternoon in D_1 (42.6 ºC) and D_3 (43.4 ºC) in crop seasons 2018 and 2019, respectively and minimum temperature was recorded at 09:00 in the morning at top of the crop canopy in D_2 (20.6 ºC) in 2018, while at top of the crop canopy in D_3 (21.3 ºC) in 2019. In both the crop seasons 2018 and 2019, among pearl millet hybrids V_4 recorded maximum temperature (43.8 ºC and 44.9 ºC) at the bottom of the crop canopy at 02:00 in the afternoon in crop season 2018 and 2019, respectively and minimum was recorded in V_1 (20.1 ºC) and (21.1 ºC) at top of the crop canopy in crop seasons 2018 and 2019, respectively.

At 50 per cent flowering in both the crop seasons 2018 and 2019 as depicted in Figs. 3 and 8, maximum temperature was recorded at the bottom of the crop canopy at 02:00 in the afternoon in D_2 (44.0 ºC) and D_3 (42.7 ºC) in crop seasons 2018 and 2019, respectively and minimum temperature was recorded at the top of the crop canopy at 09:00 in the morning in D_3 (22.1 ºC) and D_2 (22.9 ºC) in crop seasons 2018 and 2019, respectively. In both the crop seasons the maximum temperature (43.6 and 44.2 ºC) was recorded in V_4 at bottom of the crop canopy at 02:00 in the afternoon in crop seasons 2018 and 2019, respectively while minimum was recorded at the top the crop canopy at 09:00 in the morning in V_2 (25.8 ºC) and V_1 (23.4 ºC) in crop seasons 2018 and 2019, respectively.

At dough stage in both the crop seasons 2018 and 2019 as depicted in Figs. 4 and 9, maximum temperature was recorded at the bottom of the crop canopy at 0:200 in the afternoon in D_2 (42.5 ºC) and D_1 (42.5 ºC) in crop seasons 2018 and 2019, respectively and minimum temperature was recorded at the top of the crop canopy at 05:00 in the afternoon in D_1 (23.9 ºC) and D_3 (20.5 ºC) in crop seasons 2018 and 2019, respectively. In both the crop season the maximum temperature (43.9 and 44.6 ºC) was recorded in V_4 at bottom of the crop canopy at 02:00 in the afternoon in crop season 2018 and 2019, respectively while minimum was recorded at the top the crop canopy at 09:00 in the morning in V_1 (24.3 ºC) in crop season 2018, while in crop season 2019 minimum temperature recorded at top of the crop canopy at 05:00 in the afternoon in V_1 (22.4 ºC).

At physiological maturity in crop season 2018 as depicted in Fig. 5, D_1 recorded maximum temperature (41.8 ºC) at bottom of the crop canopy at 02:00 in the afternoon and minimum temperature (23.2 ºC) at top of the crop canopy at 9 in the morning, among pearl millet hybrids V_4 recorded maximum temperature (42.7 ºC) at bottom of the crop canopy at 02:00 in the afternoon while minimum temperature (25.0 ºC) was recorded in V_2 at top of the crop canopy at 09:00 in the morning. In crop season 2019 as depicted in Fig. 10, D_2 recorded maximum temperature (43.2 ºC) at bottom of the crop canopy at 02:00 in the afternoon and minimum temperature (22.7 ºC) at top of the crop canopy at 9 in the morning, among pearl millet hybrids V_4 recorded maximum temperature (45.1 ºC) at bottom of the crop canopy at 02:00 in the afternoon while minimum temperature (23.3 ºC) was recorded in V_1 at top of the crop canopy at 05:00 in the afternoon.

The prevailing temperature inside the crop canopy was higher at the bottom as compared to top of the crop canopy among in all treatments *i.e*. temperature profiles were lapse during the day inside the crop canopy. The maximum temperature was observed at 02:00 in the afternoon and the minimum was at 09:00 in the morning in both the crop seasons. This was due to the electrophile nature of the crop, facilitating the penetration of the radiation into the crop canopy which mainly consumed in heating the soil and adjacent air layers. Similar results were reported by [6].

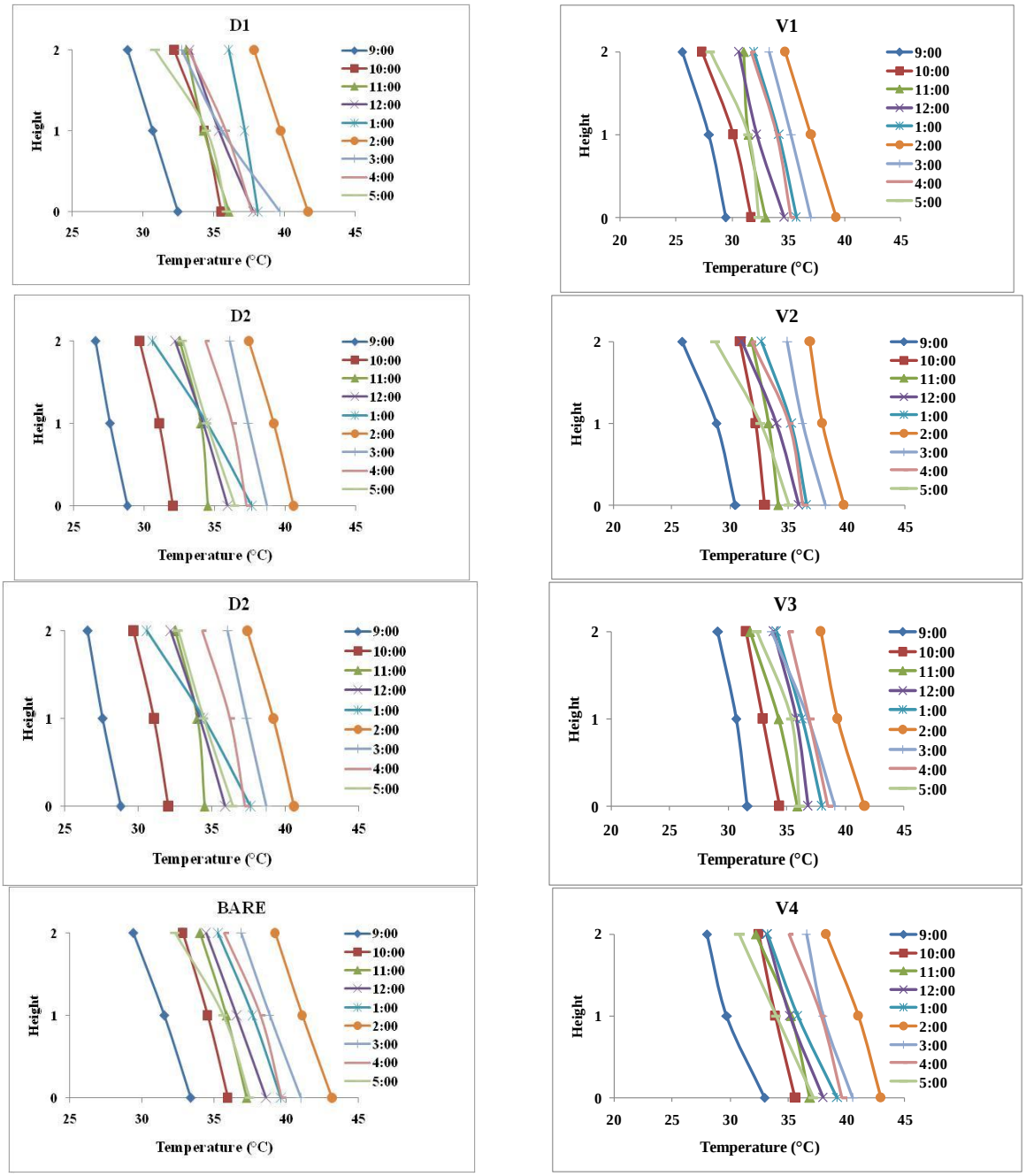

Fig. 1. Temperature profile at panicle initiation stage under different growing environments and varieties of pearl millet crop and bare soil during 2018

Where, 0=Bottom of canopy, 1=Middle of canopy, 2=Top of canopy D_1=Crop sown under 1st fortnight of June, D_2=Crop sown under 1st fortnight of July, D_3=Crop sown under 2nd fortnight of July, V_1= HHB 67 'Improved', V_2=HHB 197, V_3=HHB 272, V_4=HHB 299

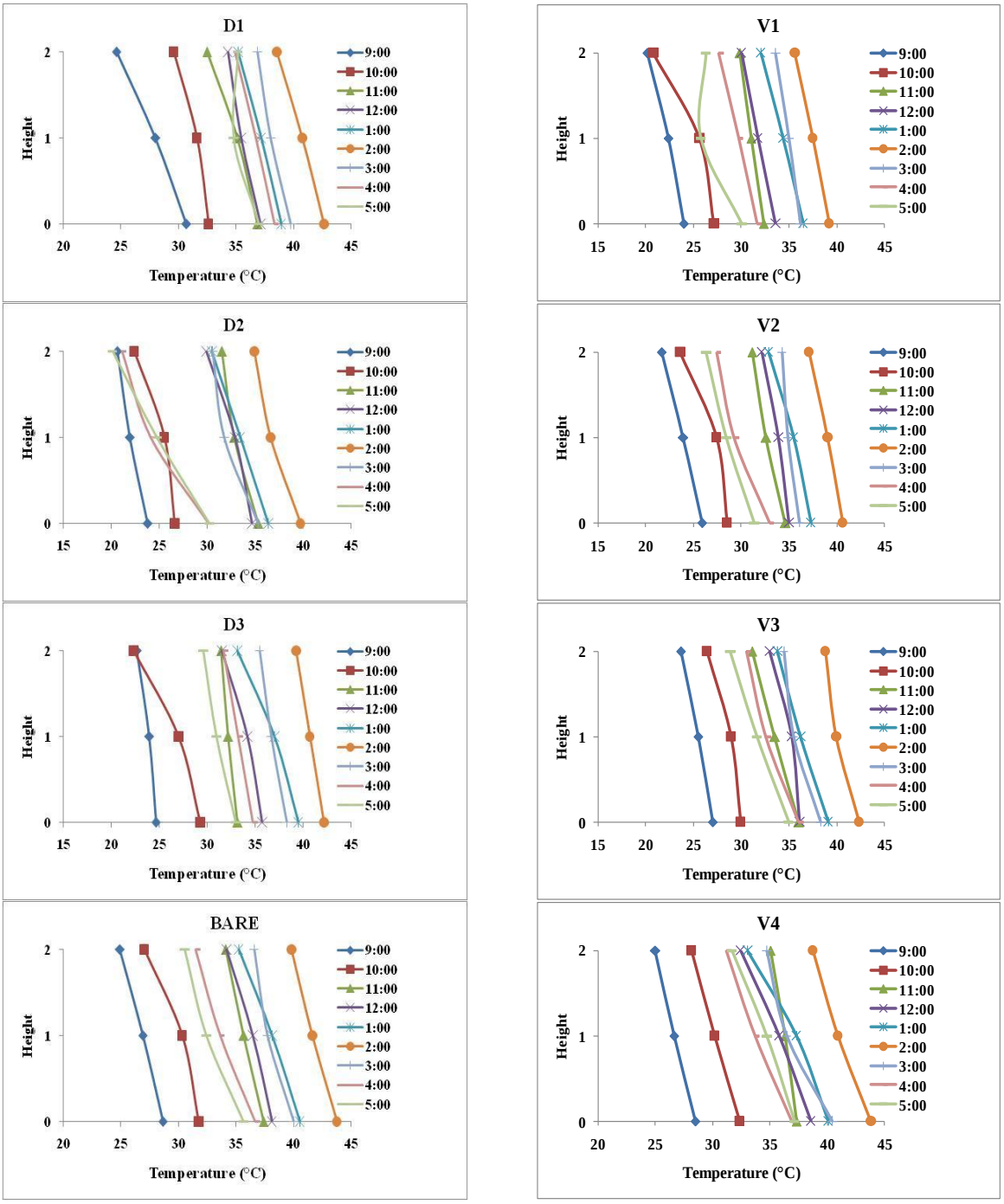

Fig. 2. Temperature profile at booting stage under different growing environments and varieties of pearl millet crop and bare soil during 2018

Where, 0=Bottom of canopy, 1=Middle of canopy, 2=Top of canopy D_1=Crop sown under 1st fortnight of June, D_2=Crop sown under 1st fortnight of July, D_3=Crop sown under 2nd fortnight of July, V_1= HHB 67 'Improved', V_2=HHB 197, V_3=HHB 272, V_4=HHB 299

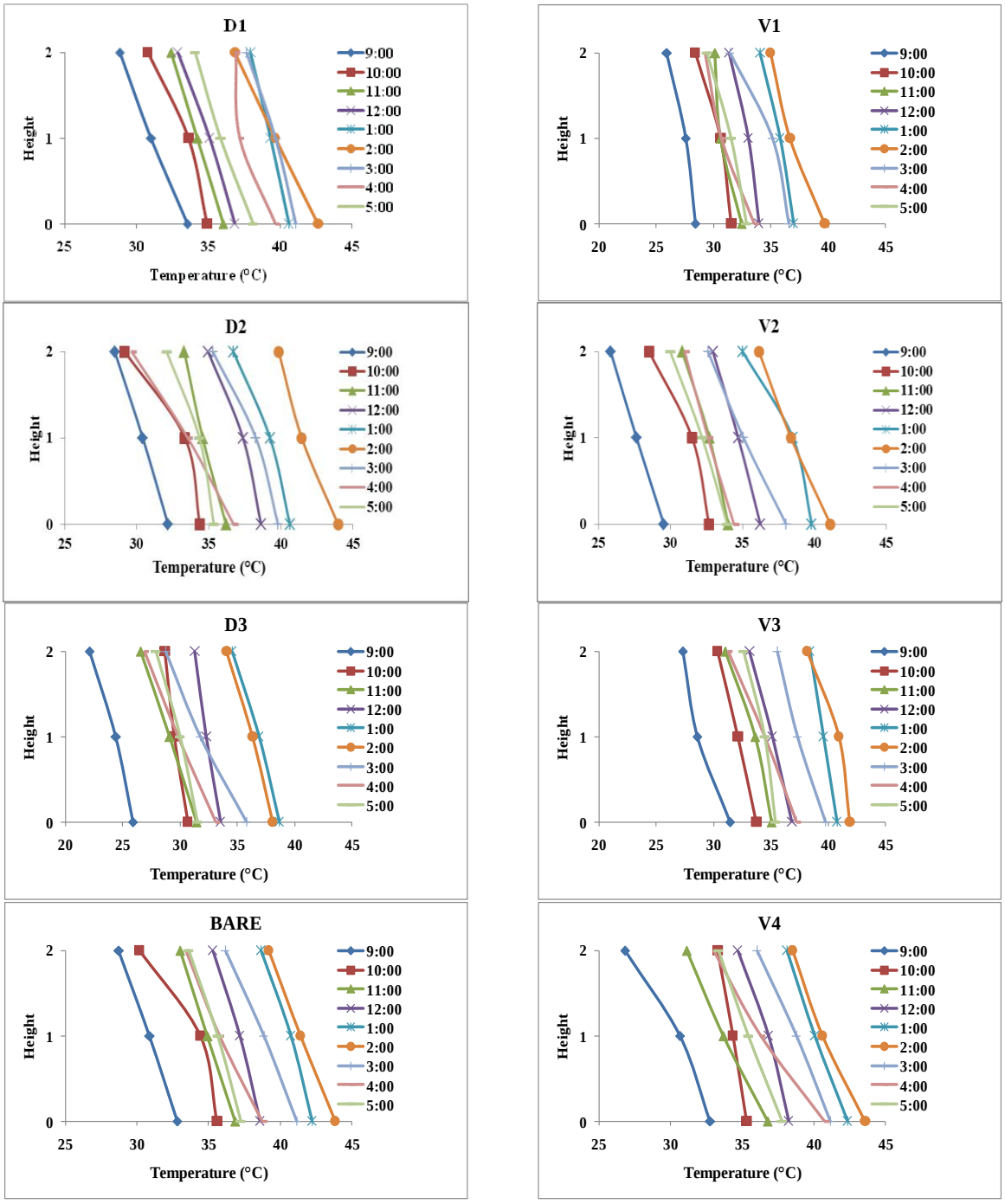

Fig. 3. Temperature profile at 50 per cent flowering stage under different growing environments and varieties of pearl millet crop and bare soil during 2018

Where, 0=Bottom of canopy, 1=Middle of canopy, 2=Top of canopy D_1=Crop sown under 1st fortnight of June, D_2=Crop sown under 1st fortnight of July, D_3=Crop sown under 2nd fortnight of July, V_1= HHB 67 'Improved', V_2=HHB 197, V_3=HHB 272, V_4=HHB 299

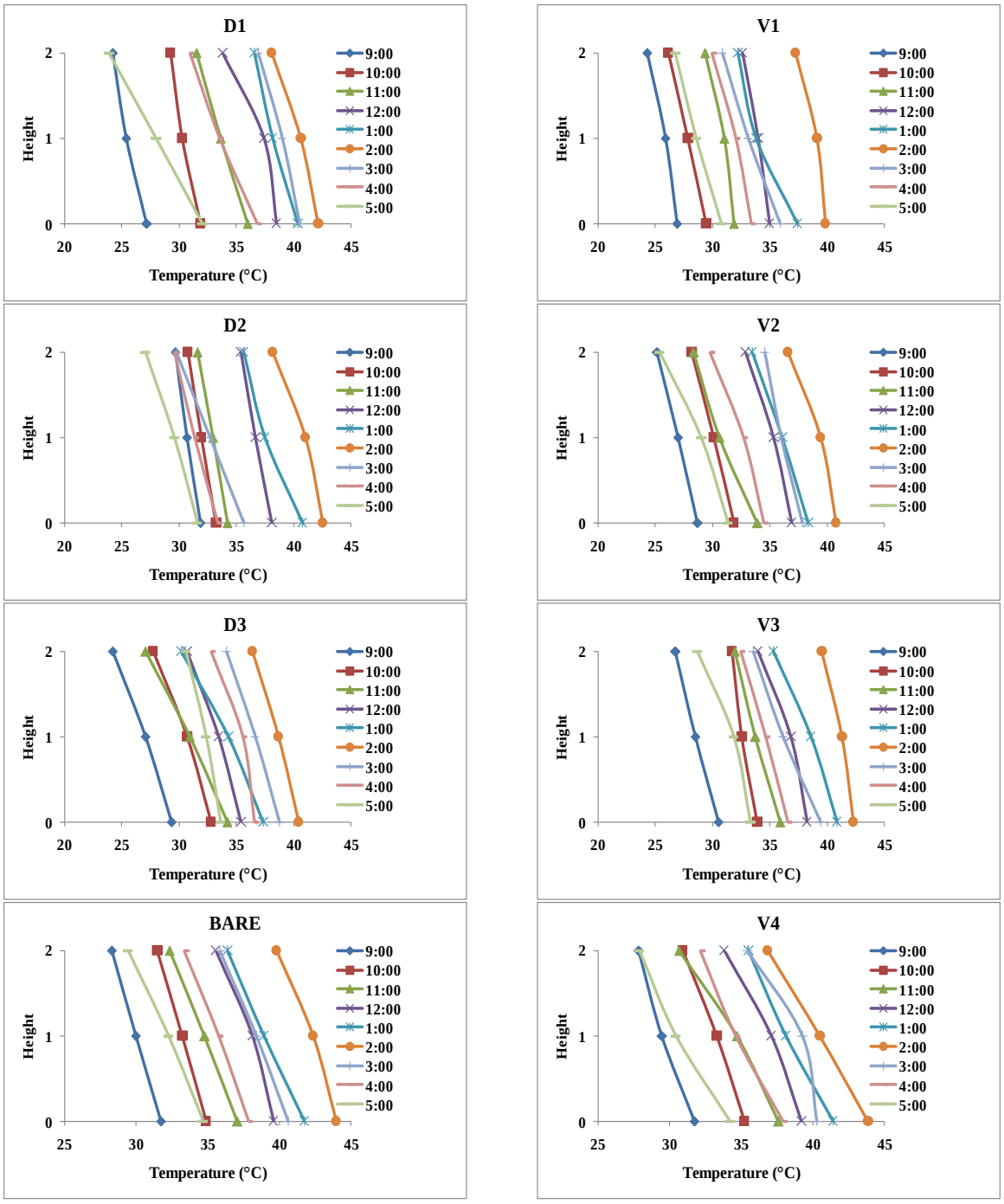

Fig. 4. Temperature profile at dough stage under different growing environments and varieties of pearl millet crop and bare soil during 2018

Where, 0=Bottom of canopy, 1=Middle of canopy, 2=Top of canopy D_1=Crop sown under 1st fortnight of June, D_2=Crop sown under 1st fortnight of July, D_3=Crop sown under 2nd fortnight of July, V_1= HHB 67 'Improved', V_2=HHB 197, V_3=HHB 272, V_4=HHB 299

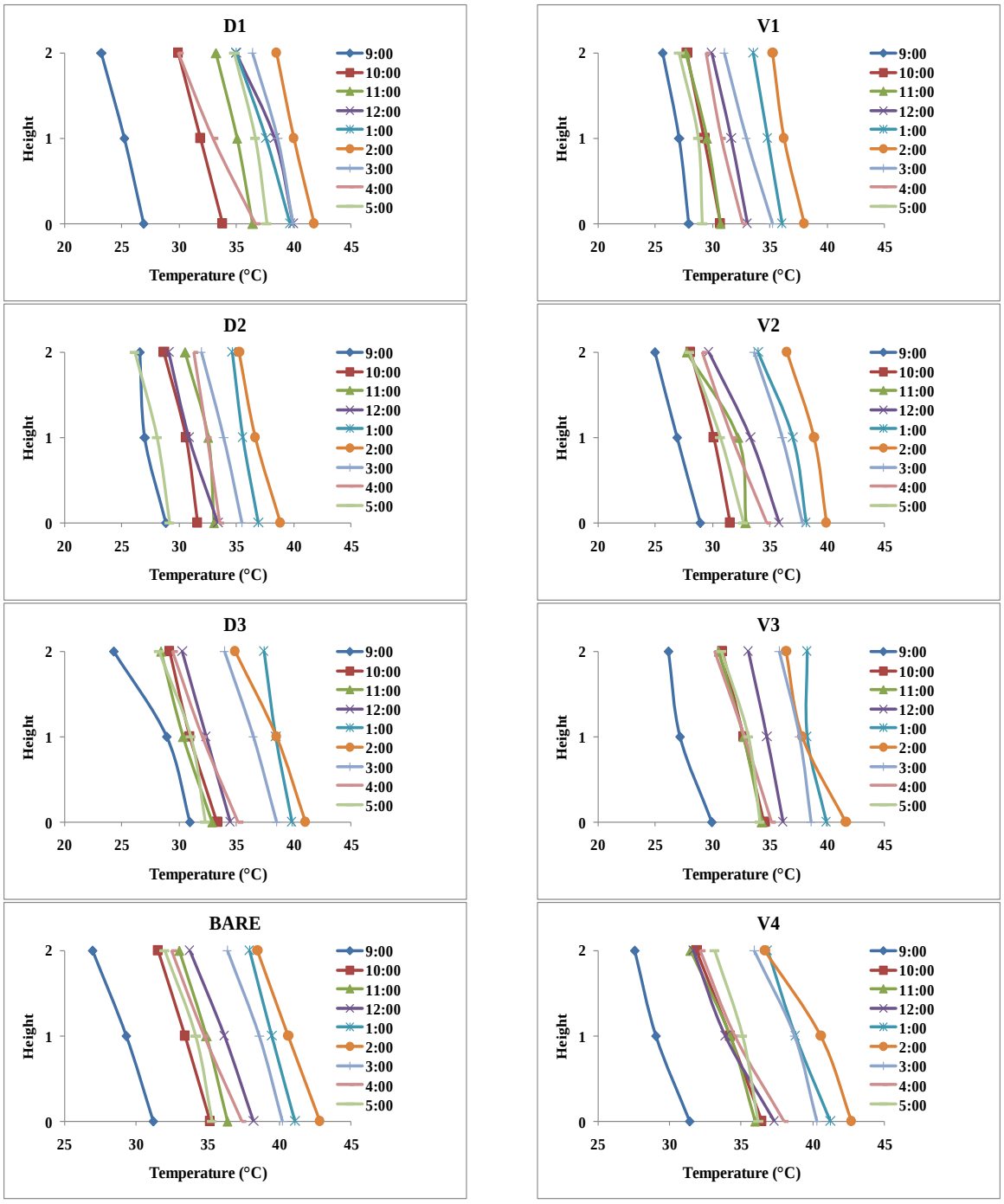

Fig. 5. Temperature profile at physiological maturity stage under different growing environments and varieties of pearl millet crop and bare soil during 2018

Where, 0=Bottom of canopy, 1=Middle of canopy, 2=Top of canopy D_1=Crop sown under 1st fortnight of June, D_2=Crop sown under 1st fortnight of July, D_3=Crop sown under 2nd fortnight of July, V_1= HHB 67 'Improved', V_2=HHB 197, V_3=HHB 272, V_4=HHB 299

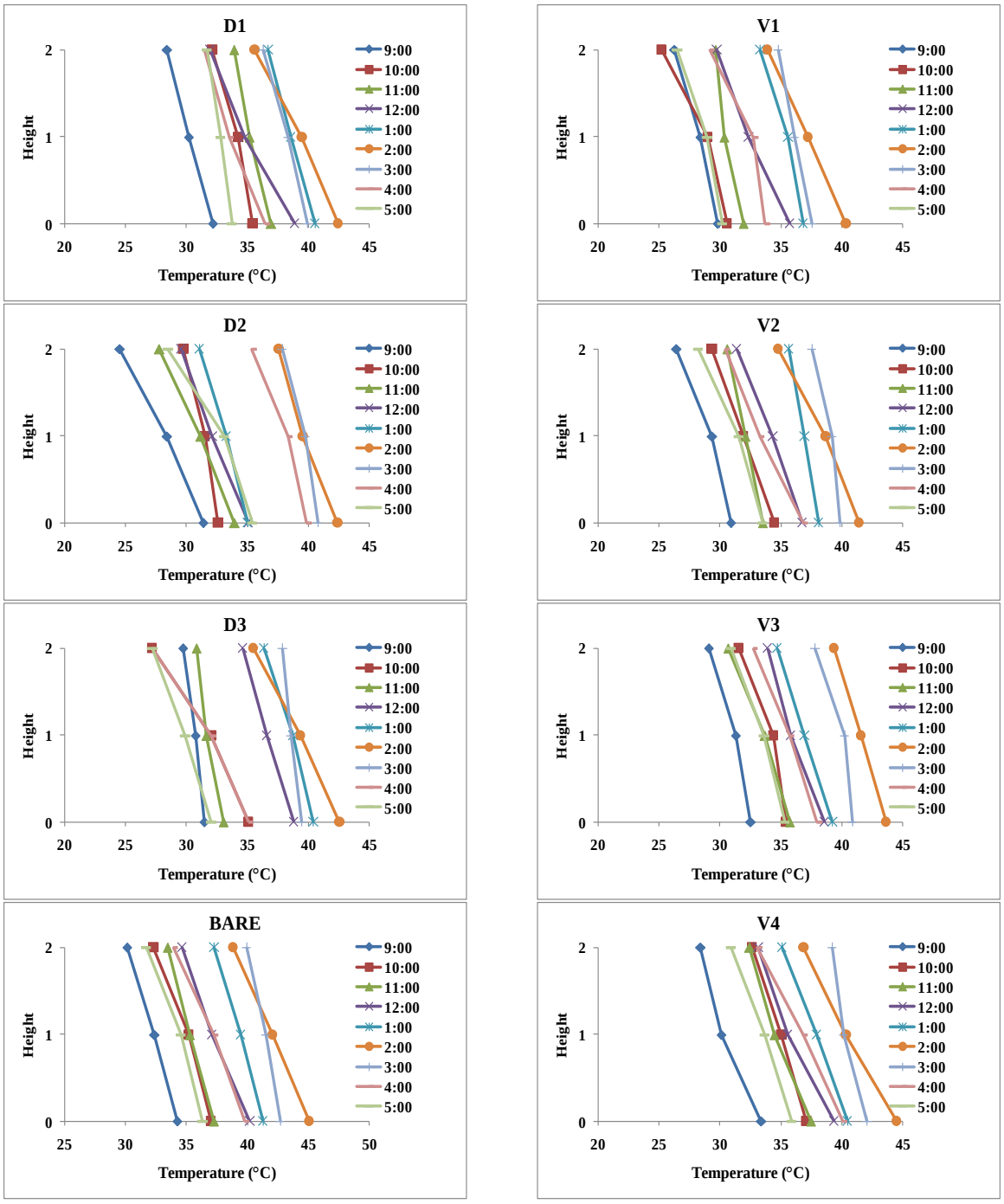

Fig. 6. Temperature profile at panicle initiation stage under different growing environments and varieties of pearl millet crop and bare soil during 2019

Where, 0=Bottom of canopy, 1=Middle of canopy, 2=Top of canopy D_1=Crop sown under 1st fortnight of June, D_2=Crop sown under 1st fortnight of July, D_3=Crop sown under 2nd fortnight of July, V_1= HHB 67 'Improved', V_2=HHB 197, V_3=HHB 272, V_4=HHB 299

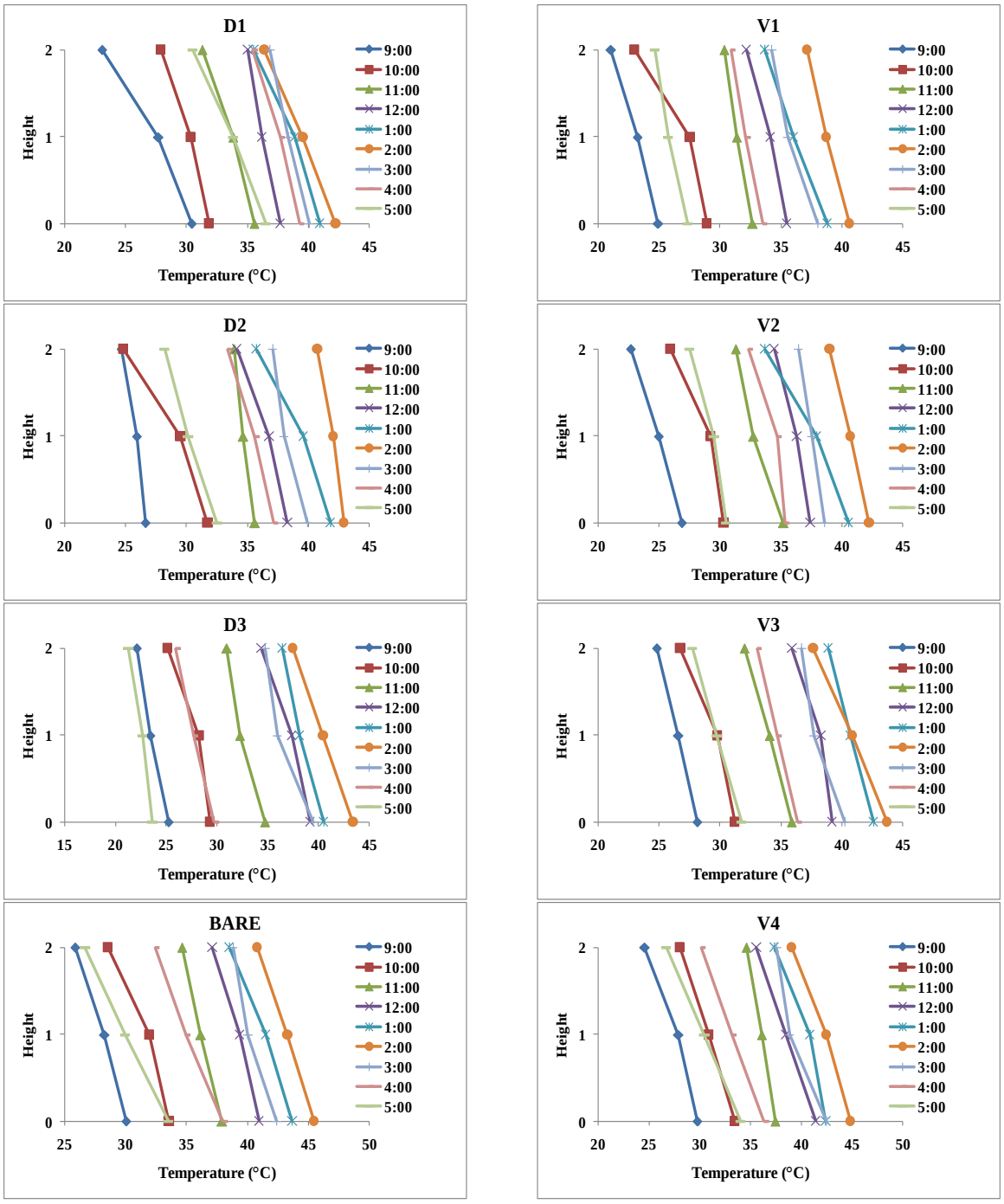

Fig. 7. Temperature profile at booting stage under different growing environments and varieties of pearl millet crop and bare soil during 2019

Where, 0=Bottom of canopy, 1=Middle of canopy, 2=Top of canopy D_1=Crop sown under 1st fortnight of June, D_2=Crop sown under 1st fortnight of July, D_3=Crop sown under 2nd fortnight of July, V_1= HHB 67 'Improved', V_2=HHB 197, V_3=HHB 272, V_4=HHB 299

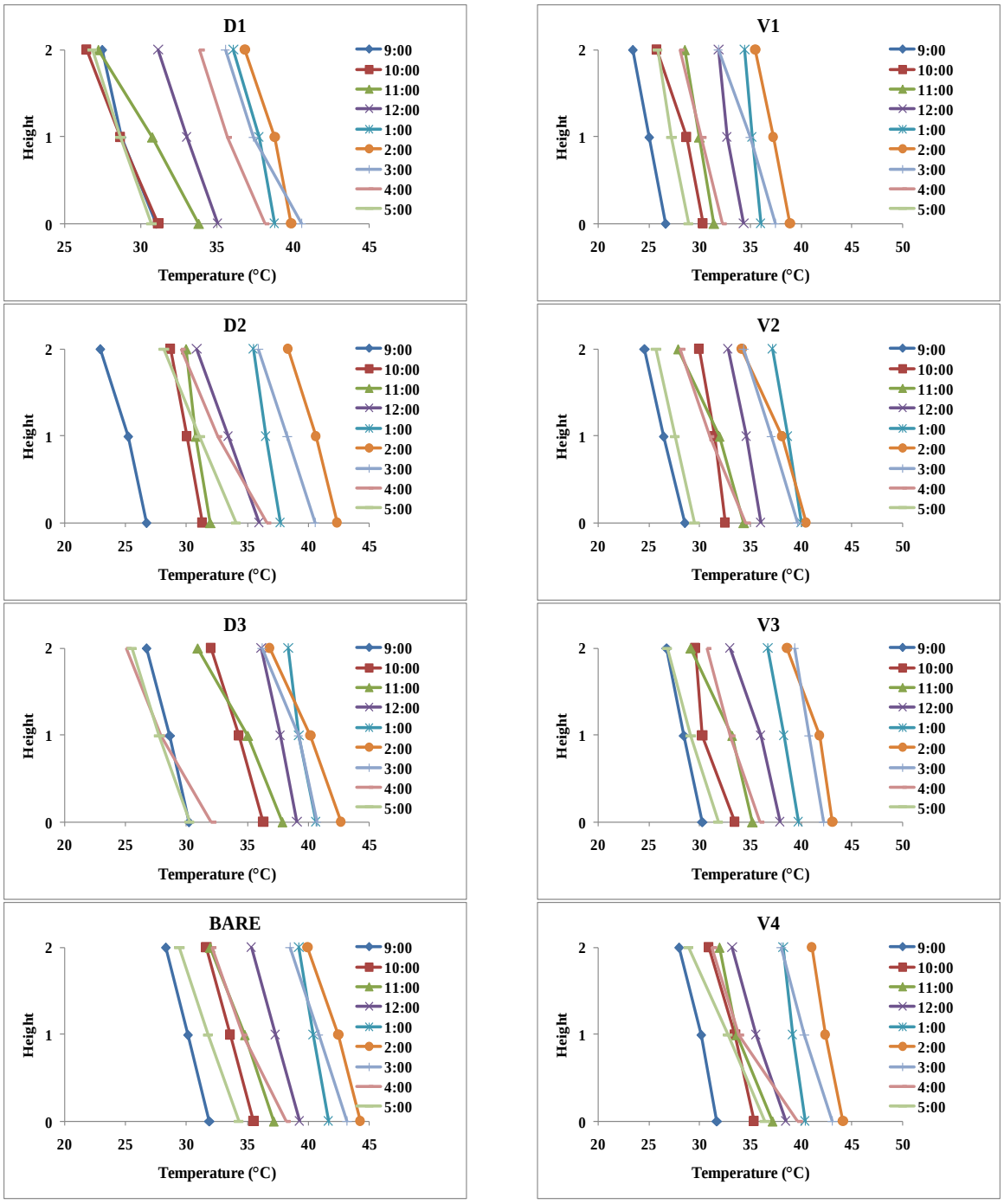

Fig. 8. Temperature profile at 50 per cent flowering stage under different growing environments and varieties of pearl millet crop and bare soil during 2019

Where, 0=Bottom of canopy, 1=Middle of canopy, 2=Top of canopy D_1=Crop sown under 1st fortnight of June, D_2=Crop sown under 1st fortnight of July, D_3=Crop sown under 2nd fortnight of July, V_1= HHB 67 'Improved', V_2=HHB 197, V_3=HHB 272, V_4=HHB 299

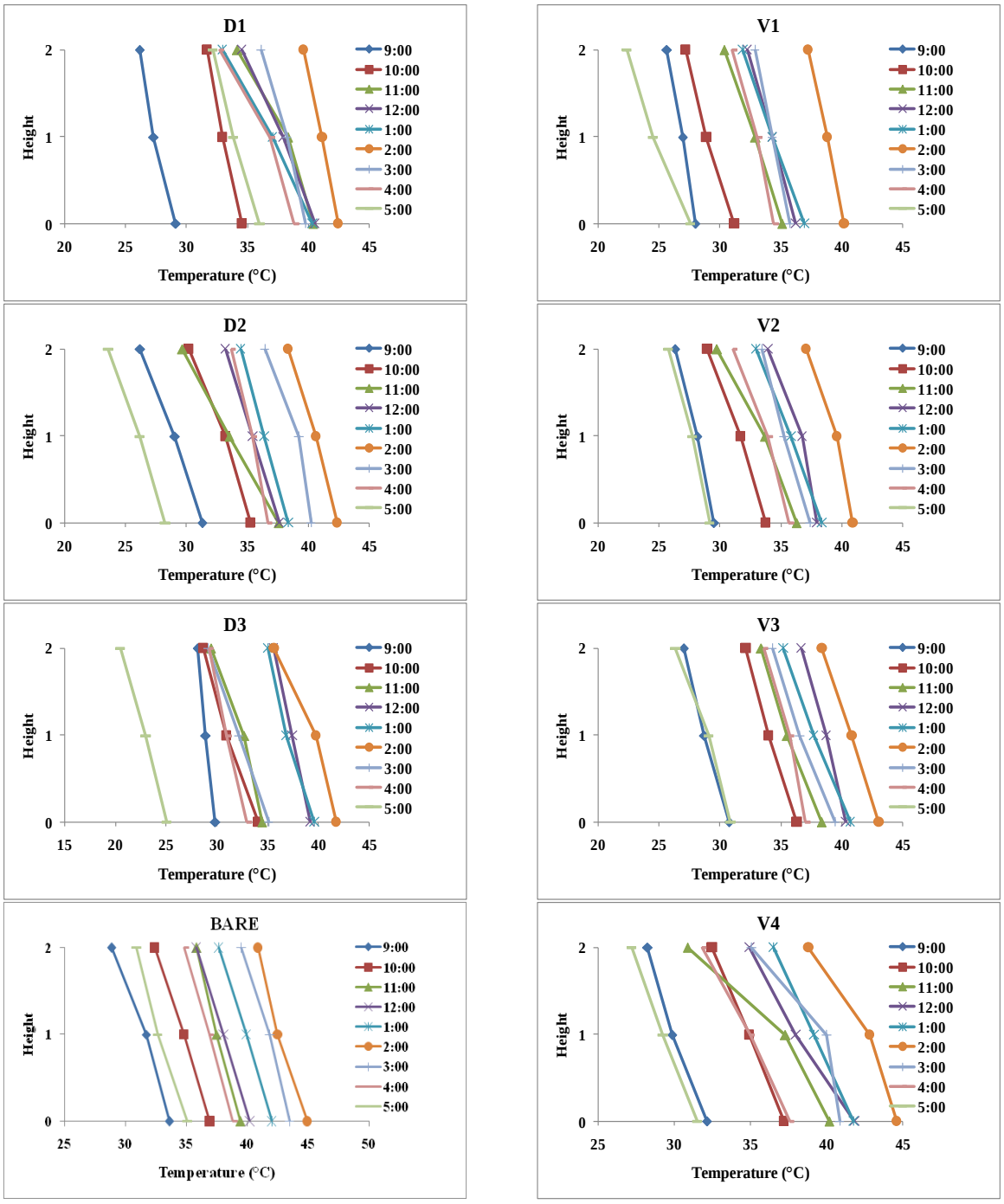

Fig. 9. Temperature profile at dough stage under different growing environments and varieties of pearl millet crop and bare soil during 2019

Where, 0=Bottom of canopy, 1=Middle of canopy, 2=Top of canopy D_1=Crop sown under 1st fortnight of June, D_2=Crop sown under 1st fortnight of July, D_3=Crop sown under 2nd fortnight of July, V_1= HHB 67 'Improved', V_2=HHB 197, V_3=HHB 272, V_4=HHB 299

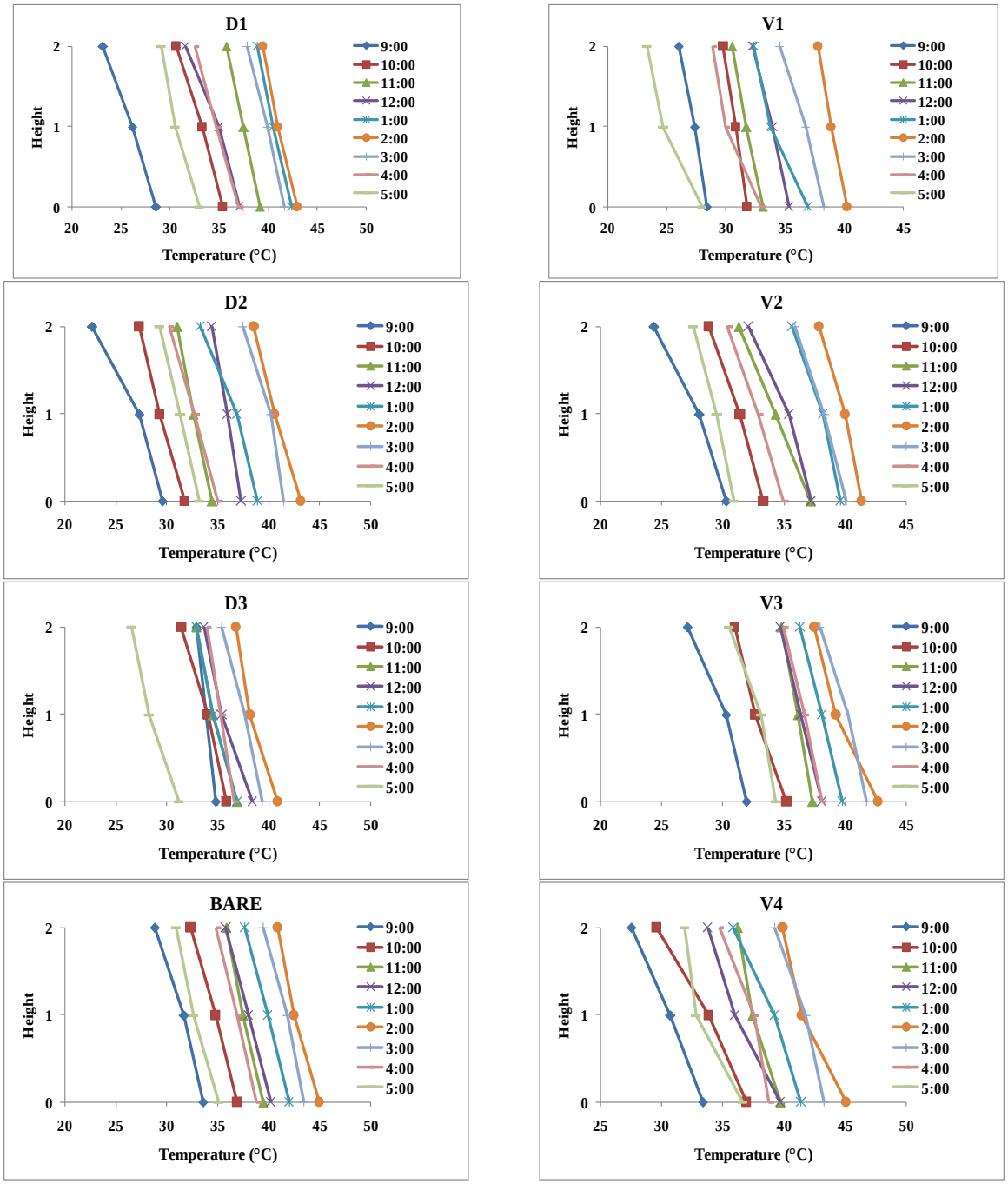

Fig. 10. Temperature profile at physiological maturity stage under different growing environments and varieties of pearl millet crop and bare soil during 2019

Where, 0=Bottom of canopy, 1=Middle of canopy, 2=Top of canopy D_1=Crop sown under 1st fortnight of June, D_2=Crop sown under 1st fortnight of July, D_3=Crop sown under 2nd fortnight of July, V_1= HHB 67 'Improved', V_2=HHB 197, V_3=HHB 272, V_4=HHB 299

4. CONCLUSION

Temperature inside the crop canopy was higher as compared to top of the crop canopy. Temperature profiles were lapse throughout the day within the crop in all treatments in both the crop seasons. More favorable weather conditions prevail with proper sowing time [7].

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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