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Microclimate and seed yield of Cluster bean varieties under two row orientations

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सार – खरीफ 2020 एवं 2021 के दौरान चौधरी चरण सिंह हरियाणा कृषि विश्वविद्यालय, हिसार के कृषि मौसम विज्ञान विभाग के अनुसंधान फार्म पर क्लस्टर बीन (ग्वार) की किस्मों में सूक्ष्म जलवायु एवं बीज उपज पर दो पंक्ति दिशाओं के प्रभाव का अध्ययन किया गया। इस प्रयोग में तीन किस्में/प्रजातियाँ शामिल थीं–V1 (HG 365), V2 (HG 563) तथा V3 (HG 2-20) और दो पंक्ति दिशाएँ–D1 (पूर्व-पश्चिम) एवं D2 (उत्तर-दक्षिण)। प्रयोग को फैक्टरियल रैण्डमाइज़्ड ब्लॉक डिज़ाइन में तीन पुनरावृत्तियों के साथ स्थापित किया गया।सभी उपचारों में फसल की प्रमुख अवस्थाओं पर फसल छत्र (कैनोपी) के भीतर तापमान एवं आर्द्रता के दैनिक (डायर्नल) प्रोफाइल मापने के लिए अस्मान साइकोमीटर का उपयोग किया गया। प्राप्त प्रोफाइल से यह स्पष्ट हुआ कि छत्र के निचले भाग में दैनिक परिवर्तन न्यूनतम तथा ऊपरी भाग में अधिकतम थे। छत्र का ऊपरी भाग निचले भाग की तुलना में परिवेशी वातावरण के अधिक निकट पाया गया।उत्तर-दक्षिण दिशा में बोई गई फसल में पूर्व-पश्चिम दिशा में बोई गई फसल की तुलना में प्रकाश संश्लेषणीय सक्रिय विकिरण (PAR) का अवरोधन थोड़ा अधिक था, हालांकि यह अंतर सांख्यिकीय रूप से महत्वपूर्ण नहीं था। क्लस्टर बीन की किस्म HG 2-20 ने अन्य किस्मों की तुलना में अधिक PAR का अवरोधन किया।उत्तर-दक्षिण पंक्ति दिशा में बोई गई फसल में प्रति पौधा अधिक फली संख्या के कारण बीज उपज अधिक प्राप्त हुई, जबकि पूर्व-पश्चिम पंक्ति दिशा में उपज अपेक्षाकृत कम रही। इसी प्रकार, किस्म HG 2-20 में प्रति पौधा अधिक फलियों के कारण बीज उपज सर्वाधिक पाई गई।

ABSTRACT. An investigation on microclimate and seed yield of Cluster bean cultivars under two row orientations was conducted during Kharif 2020 and 2021, at the Research Farm, Department of Agricultural Meteorology, Chaudhary Charan Singh Haryana Agricultural University, Hisar. The treatment comprised of three cultivars/varieties V1 (HG 365), V2 (HG563) and V3 (HG 2-20) and two row orientations D1 (East-West) and D2 (North-South) which were replicated thrice in factorial randomized bock design. Assmann psychrometer was used to measure the diurnal profiles of temperature and humidity the crop canopy in all the treatments at important phenophases. The profiles showed lowest diurnal variations at the bottom of the canopy and highest at the top of the canopy. The top of the canopy was much closer to the ambient environment as compared to the bottom of the canopy. Intercepted Photo-synthetically active radiation was a little higher in the North-South shown crop in comparison to the East-West sown crop, however, it is not statistically significant. Variety HG 2-20 intercepted more PAR in comparison to other cluster bean varieties. The North-South crop row orientation had a higher seed yield owing to its greater number of pods/plantpods/plant in comparison to the East-West crop row orientation. The cultivar HG 2-20 had a higher seed yield due to more pods/plant.

Key words – Cluster bean, Microclimate, Radiation interception, Crop row orientation, Temperature and relative humidity profiles.

1. Introduction

Cluster bean or guar (*Cyamopsis tetragonoloba* (L.) Taub.) is a legume plant widely grown for its gum, vegetable, fodder and green manure values. It is a member of the family Leguminosae. Cluster beans have been grown in India since ancient time. There are several wild plants related to cluster beans in Africa suggesting that it is most probably of African origin (Mudgil *et al.,* 2011). It is possible that cluster beans were domesticated very early in Africa and Arabia and made their way to the Indian subcontinent.

India leads all other countries in both the cultivation and production of cluster beans in the world. It contributes to some 80% of the world's total Guar production. In India, the total area of guar cultivation was 40,60,010 ha and total production was 18,05,220 tons yielding about 4.45 q/ha in 2016-17 (Yogi *et al.,* 2020). If Haryana is considered the area, production and yield of Guar seed was 2,72,500 ha, 2,26,700 tons and 8.17 q/ha respectively (Haryana Government, 2019). In Rajasthan, production and average yield of Guar stood at 34,32,392 ha, 12,65,141 tons and 3.69 q/ha respectively for the year 2017-18 (Rajasthan Agricultural Statistics, 2020). India is among the top exporters of guar gum to the world; it exports various forms of Guar products to a large number of countries. The country has exported 4.17 lakh tons of guar gum in the world at a worth of Rs 4489.40 crores/ USD 541.65 million during the year 2023-24 (APEDA, 2024).

Guar produces a natural hydrocolloid which is a cold water-soluble substance that creates a dense solution even in low concentrations. The guar seed is comprised of three components: the germ (43-47%), the endosperm (35-42%), and the seed coat (14-17%). The endosperm, which is spherical in shape, contains substantial quantities of galactomannan gum (19 to 43% of the entire seed), and is the primary commercial product derived from this crop (Mudgil *et al.,* 2011). Similar to other legumes, guar possesses exceptional soil-building properties due to its ability to fix nitrogen. Nitrogen-fixing bacteria reside in the root nodules of the plant, and when the crop residues are incorporated into the soil through ploughing, it enhances the productivity of subsequent crops (Pathak, 2015). Pod yield per plant and pod length at genotypic level exhibit high positive direct effect on seed yield per plant in Guar (Nampelli, 2016).

Being a tropical plant, cluster bean is a warm season crop. For proper germination, the crop requires 30 to 35 ºC temperatures during sowing time and a temperature of 32 to 38 ºC encourages good vegetative growth. However, high temperatures can cause pre-mature drop of flowers at flowering stage. Temperatures as high as 45-46 ºC can be tolerated by cluster bean. It is an indeterminate and photo sensitive crop (Meena, 2014).

Crop row orientation has been found to cause a significant impact on grain yield, biomass, leaf fresh weight, harvest index and fruit fresh weight in many pulses such as mung bean (Monem, 2012), so yield in guar is also expected to be higher in the row orientation that permits more light penetration by upper leaves to the lower leaves given that this light does not causes excess weed growth.

As seen in many other crops, Guar is also dependent on favourable weather parameters for higher yield. Pod filling and late vegetative phases when coupled with high photosynthetically active radiation have shown a marked increase in seed yield in many other legumes such as Pigeon pea (Patel *et al.*, 2000).

Hence, this study, in particular was conducted to measure the microclimate and seed yield of Cluster bean cultivars under two row orientations.

2. Data and methodology

2.1. *Study location and climatic conditions*

The experiment was carried out at Research farm, Department of Agricultural Meteorology, CCS Haryana Agricultural University, Hisar, which is situated in the sub-tropics at longitude 75° 46´ E, latitude 29° 1´ N and at a mean sea level elevation of 215.2 meters during the *Kharif* season 2020-21. This area is a part of the alluvial Ghaggar-Yamuna plain and its southern and western portions mark a gradual transition to the desert. The climate of Hisar is a semi-arid subtropical monsoonal climate. Relative humidity varies from 25 to 100%. The South west monsoon brings rain generally from the end of June to mid-September. The average rainfall is 460 mm per annum. About 75% of this precipitation is received during the South west monsoon season. From October to the end of June, the weather remains mostly dry, except for a few winter showers received because of western disturbances.

2.2. *Soil characteristics of the experimental sites*

The soil of the experimental site was sandy loam in texture. There was not any variation in the soil fertility status of soil over the experimental area. The soil is moderately coloured and well drained. The N, P and K contents in the soil are low, low to medium and medium to high respectively. The soil has sufficient content of Fe, Cu, Zn and Mn to supply the crop.

2.3. *Experimental treatments*

Crop row orientation and its effect on the microclimate has gained attention in recent times. Three common cluster bean varieties recommended under Hisar conditions: HG 365: V1, HG 563: V2, HG 2-20: V3 were grown under two crop row orientations: D1: East-West and D2: North-South. There were three replications of the treatments under factorial randomized block design. Weather data of T_{min}, T_{max}, RH_m, RH_e and Rainfall were taken from the agro-meteorological observatory situated at the research farm. The crop was harvested after maturity and the seed yield and seed yield's parameters were recorded on a per plant basis. The crop was grown for 2 successive years of *Kharif* 2020 and *Kharif* 2021.

2.4. *Micrometeorological observations*

For the study of microclimatic effects under two crop row orientations in cluster bean, within-canopy temperature and humidity were measured at the top and bottom during the vegetative stage, and at the top, middle, and bottom during the flowering and pod formation stages. Intercepted Photosynthetically active radiation (PAR) was measured during the noon hours at top and bottom of the canopy with a Line quantum sensor. The micrometeorological observations within the crop canopy were recorded at 0800 hrs, 1200 hrs, 1400 hrs and 1600 hrs by Assmann psychometer.

3. Results and discussions

3.1. *Temperature profile*

Diurnal temperature profiles of different cluster bean cultivars (HG 365, HG 563 and HG 2-20) under two crop row orientations (North-South and East-West) at vegetative, flowering and pod formation phenophases are depicted in Figs. 1, 2 and 3 for *Kharif* 2020 and in Figs. 4, 5 and 6 for *Kharif* 2021. As the height of plants was less at vegetative stage, temperature of only the top and bottom of the canopy was taken. In later stages, temperature at the centre of the canopy height was also measured.

The range of temperature was highest at 1400 hrs and the lowest at 0800 hrs with temperature values at 1200 hrs and 1600 hrs lying in between. Overall, there was more variation in temperature in the upper canopy and least at the bottom of the canopy. This is due to much more free connection of the upper canopy with the overlying air.

Minimum diurnal temperature was measured at 0800 hrs and the maximum at 1400 hrs in all three varieties and in both crop row orientations. Morning time (0800 hrs) profiles were almost vertical. Afternoon time temperature profiles (1400 hrs) were inverse, which indicates an increase in temperature with height. East-West crop row orientation, had a somewhat lower middle temperature in comparison to North-South crop row orientation The reason for this is probably the inter-row shading effect caused in East-West crop row orientations.

HG 2-20 had a lower bottom temperature in comparison to the other two varieties in flowering and pod formation stages. This is a clear result of much denser crop canopy due to it having more branches and a lower average height as studied by Satpal *et al.* (2018).

At the vegetative stage, the difference between top and bottom canopy temperature was not as pronounced as that in the flowering and pod formation stage. In the flowering stage the temperature at the top was close to ambient temperature. It then fell rapidly when moving to the middle of the canopy and only slightly at the bottom of canopy. When looking at the pod formation stage, it was also observed that the temperature more or less fell from the highest at the top of the canopy to the lowest at the bottom of the canopy. The diurnal temperature range at bottom canopy level was less at the flowering stage in comparison to other phenological stages. The variations in temperature within profile at different time of day at different growth stages remain more of less the same during both years of cultivation.

3.2. *Relative Humidity profile*

Diurnal relative humidity profiles of different cluster bean cultivars (HG 365, HG 563 and HG 2-20) under two crop row orientations (North-South and East-West) in vegetative, flowering and pod formation phenophases are shown in Figs. 7, 8 and 9 for *Kharif* 2020 and in Figs. 10, 11 and 12 for *Kharif* 2021. As the height of plants was less in vegetative stage, relative humidity of only the top and bottom of the canopy was taken. In later stages, relative humidity in the middle of the canopy was also measured.

The range of relative humidity was highest at 1400 hrs and the lowest at 0800 hrs with relative humidity values at 1200 hrs and 1600 hrs lying in between. Like temperature, there was a more variation in relative humidity in the upper canopy and least in the bottom of the canopy. A similar result in the case of temperature profiles was observed by Dhir *et al.* (2020) in *Bt* cotton.

Maximum diurnal relative humidity was measured at 0800 hrs and minimum at 1400 hrs in all three varieties and in both crop row orientations during both years of

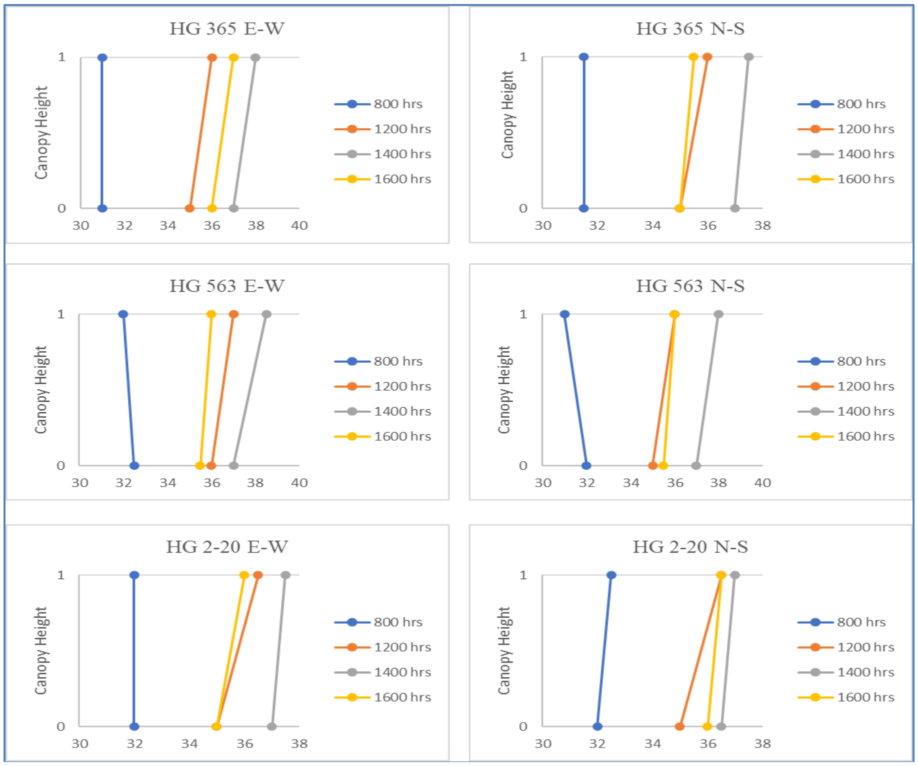

Fig. 1. Diurnal temperature (˚C) profiles in cluster bean cultivars under two crop row orientations at vegetative stage during *Kharif* 2020 **(**On Y-axis, "0" and "1" indicate "Bottom" and "Top" respectively, X-axis is temperature in °Celsius)

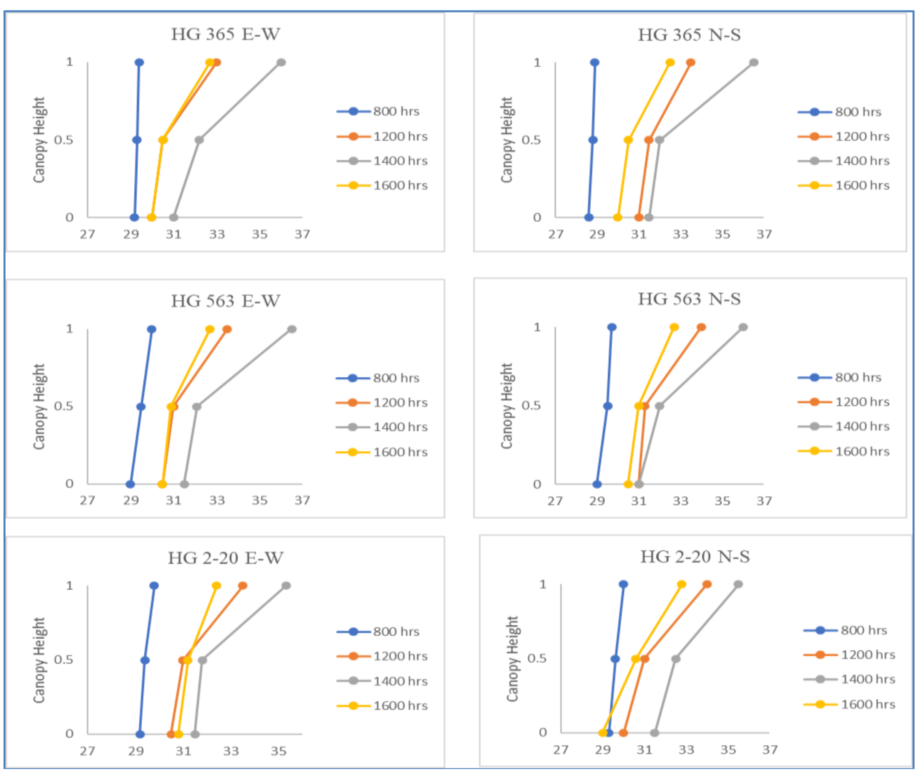

Fig. 2. Diurnal temperature (˚C) profiles in cluster bean cultivars under two crop row orientations at flowering stage during *Kharif* 2020 (On Y-axis, "0", "0.5" and "1" indicate "Bottom", "Middle" and "Top" respectively, X-axis is temperature in °Celsius)

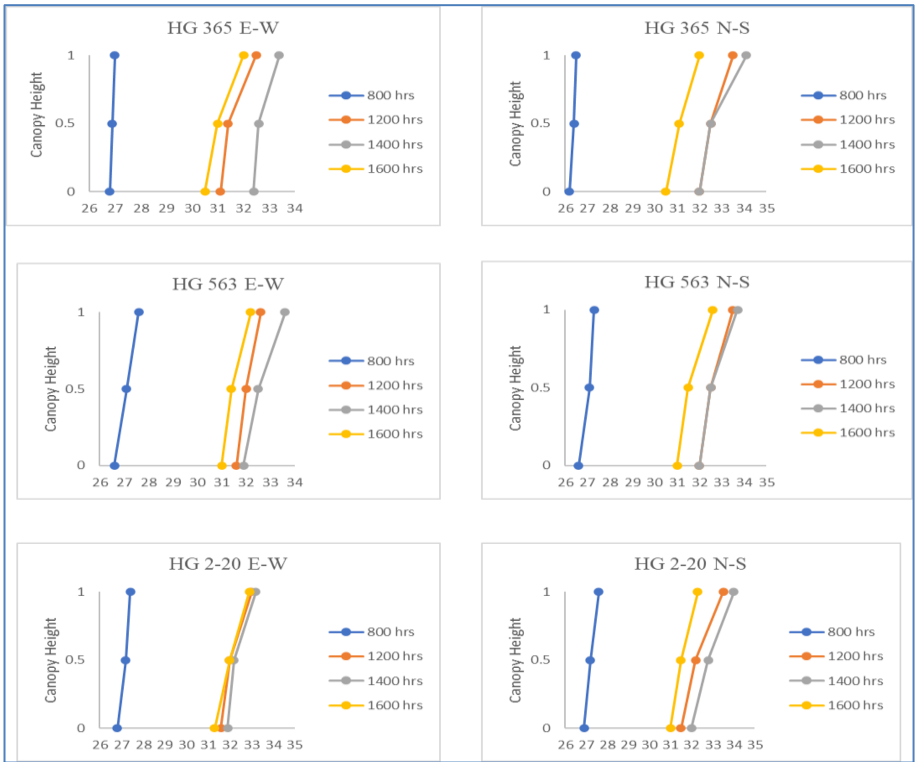

Fig. 3. Temperature (˚C) profiles of different cluster bean cultivars in two crop row orientations at pod formation stage during *Kharif* 2020 (On Y-axis, “0”, “0.5” and “1” indicate “Bottom”, “Middle” and “Top” respectively, X-axis is temperature in °Celsius)

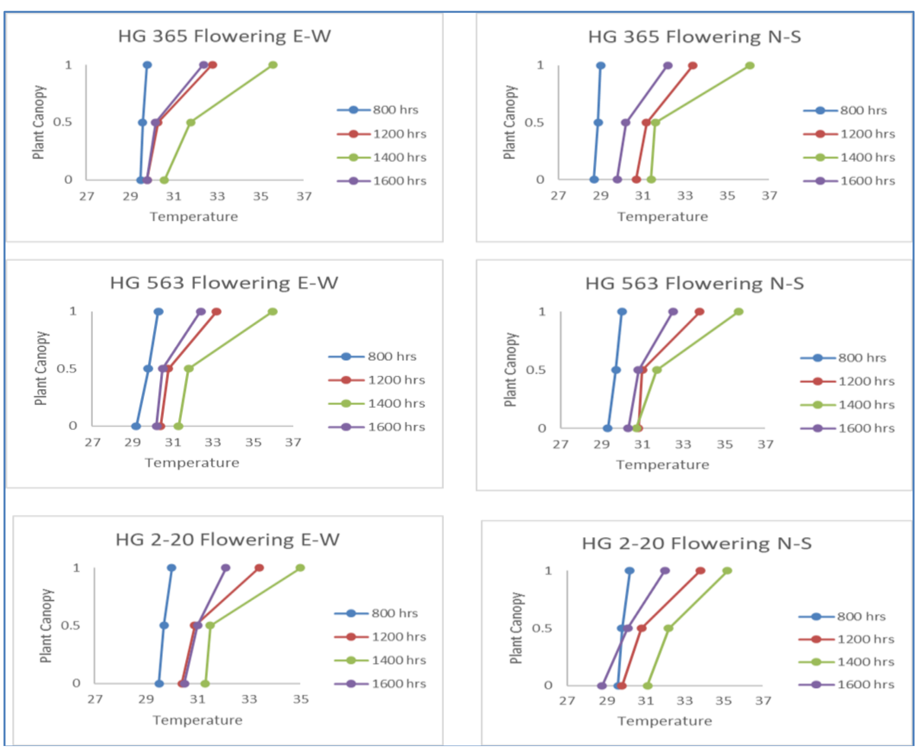

Fig. 4. Temperature (˚C) profiles of different cluster bean cultivars in two crop row orientations at vegetative stage during *Kharif* 2021 (On Y-axis, “0”, “0.5” and “1” indicate “Bottom”, “Middle” and “Top” respectively, X-axis is temperature in °Celsius)

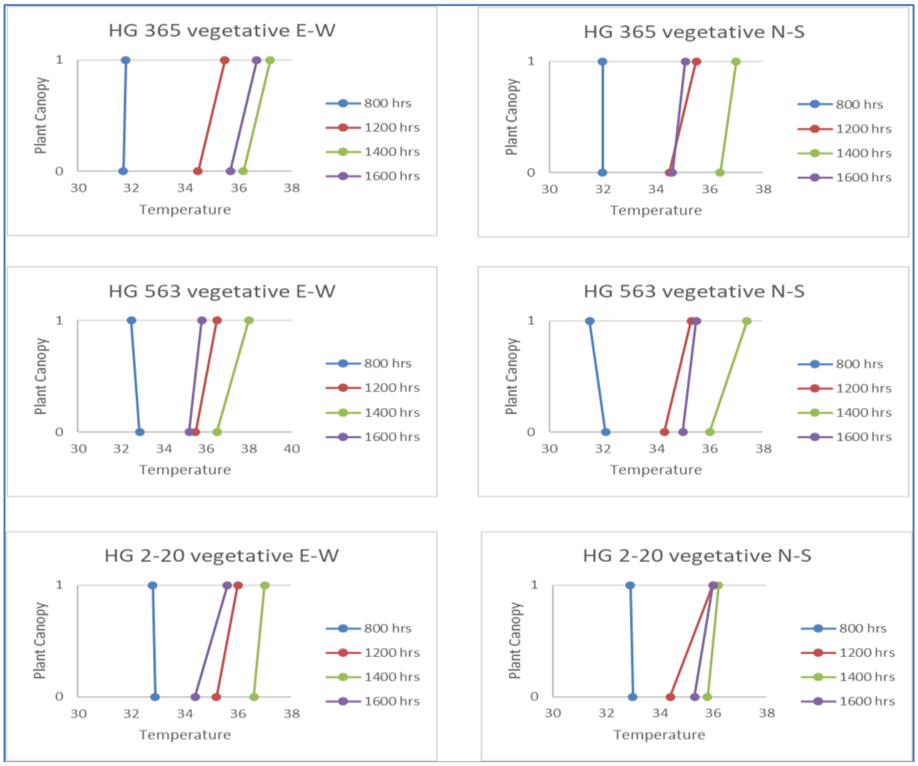

Fig. 5. Temperature (˚C) profiles of different cluster bean cultivars in two crop row orientations at flowering stage during Kharif 2021 (On Y-axis, "0", "0.5" and "1" indicate "Bottom", "Middle" and "Top" respectively, X-axis is temperature in °Celsius

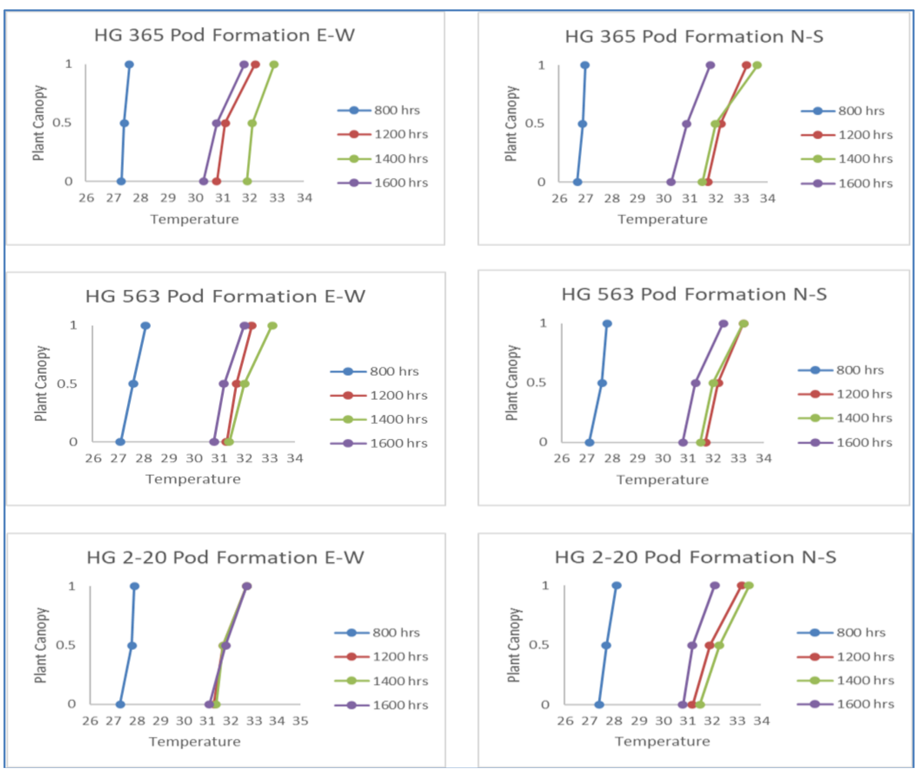

Fig. 6. Temperature (˚C) profiles of different cluster bean cultivars in two crop row orientations at pod formation stage during *Kharif* 2021 (On Y-axis, "0", "0.5" and "1" indicate "Bottom", "Middle" and "Top" respectively, X-axis is temperature in °Celsius

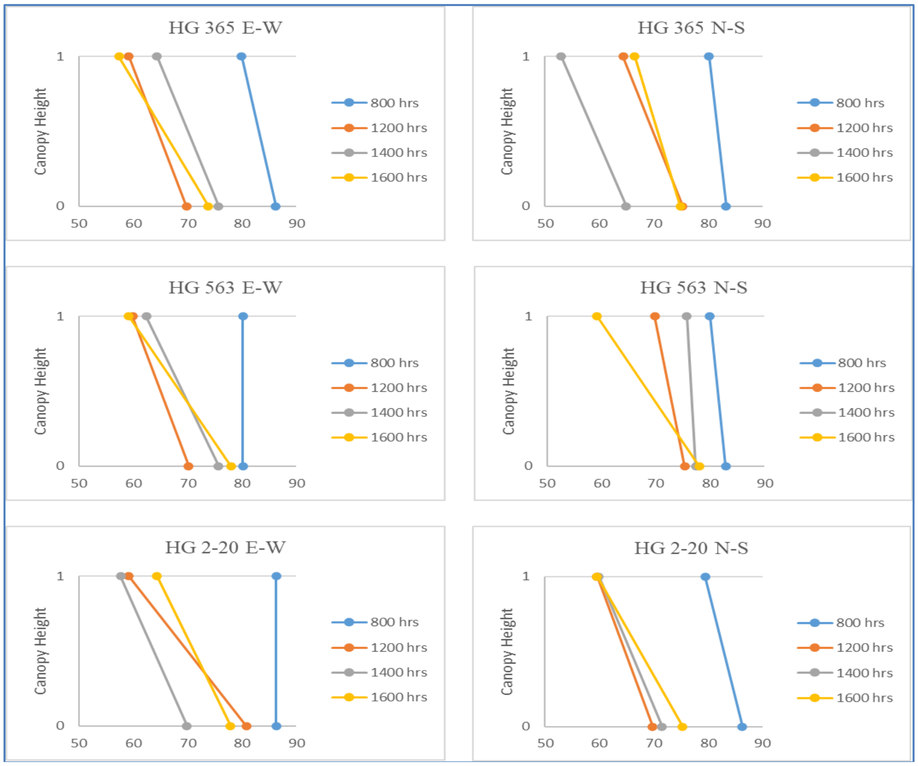

Fig. 7. Relative Humidity (%) profiles in cluster bean cultivars under two crop row orientations at vegetative stage during *Kharif* 2020 **(**On Y-axis, "0" and "1" indicate "Bottom" and "Top" respectively, X-axis is temperature in °Celsius)

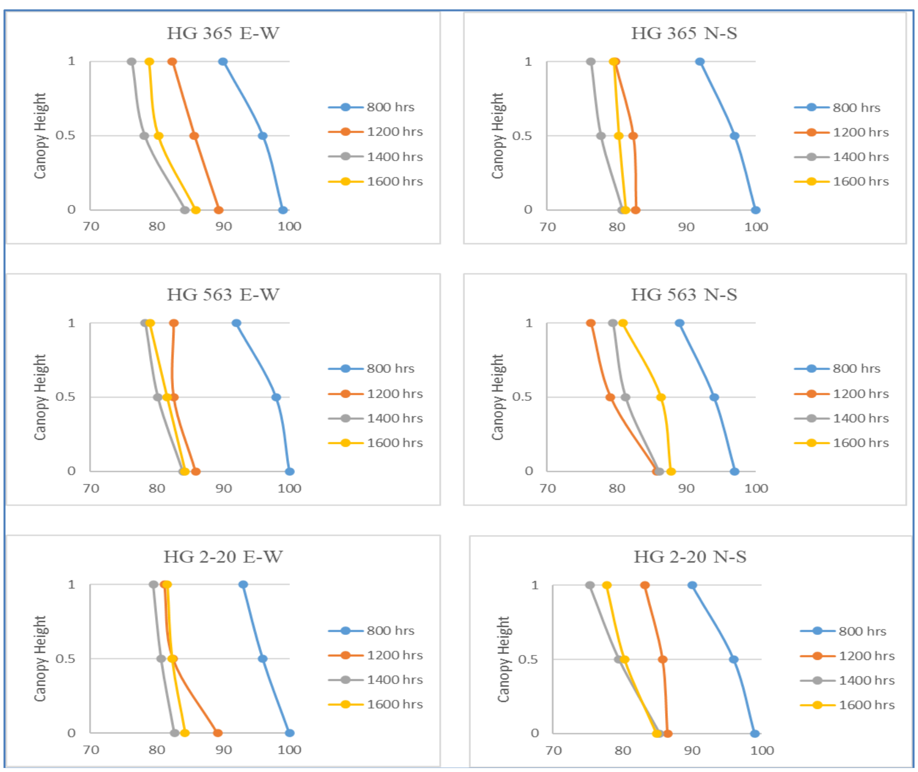

Fig. 8. Relative Humidity (%) profiles in cluster bean cultivars under two crop row orientations at flowering stage during *Kharif* 2020 **(**On Y-axis, "0", "0.5" and "1" indicate "Bottom", "Middle", and "Top" respectively, X-axis is temperature in °Celsius)

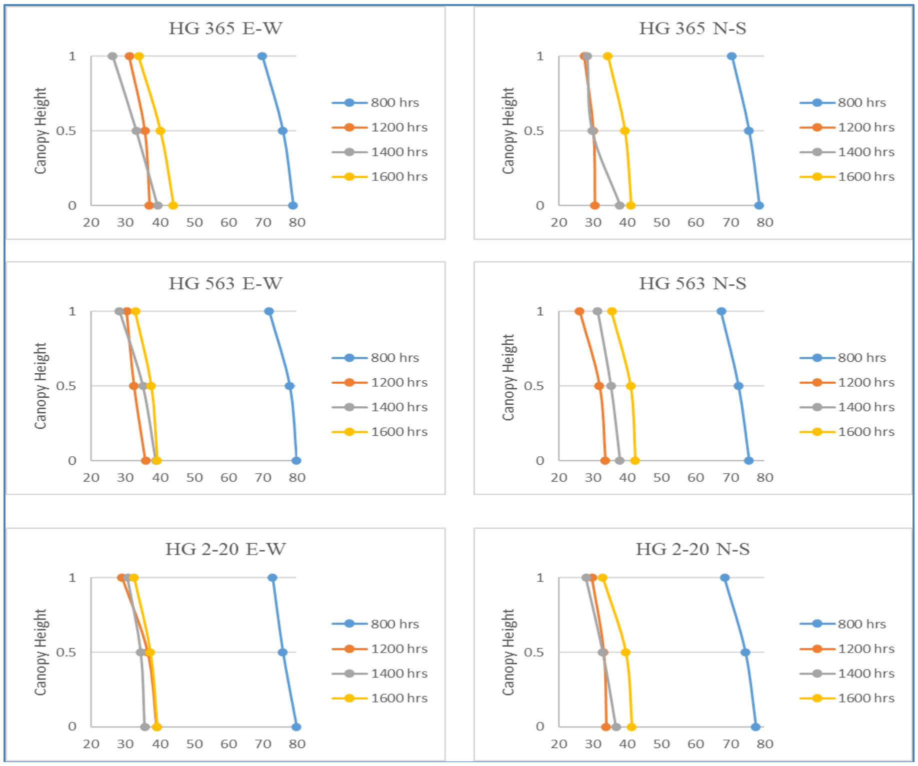

Fig. 9. Relative Humidity (%) profiles in cluster bean cultivars under two crop row orientations at pod formation stage during *Kharif* 2020 (On Y-axis, "0", "0.5" and "1" indicate "Bottom", "Middle" and "Top" respectively, X-axis is temperature in °Celsius

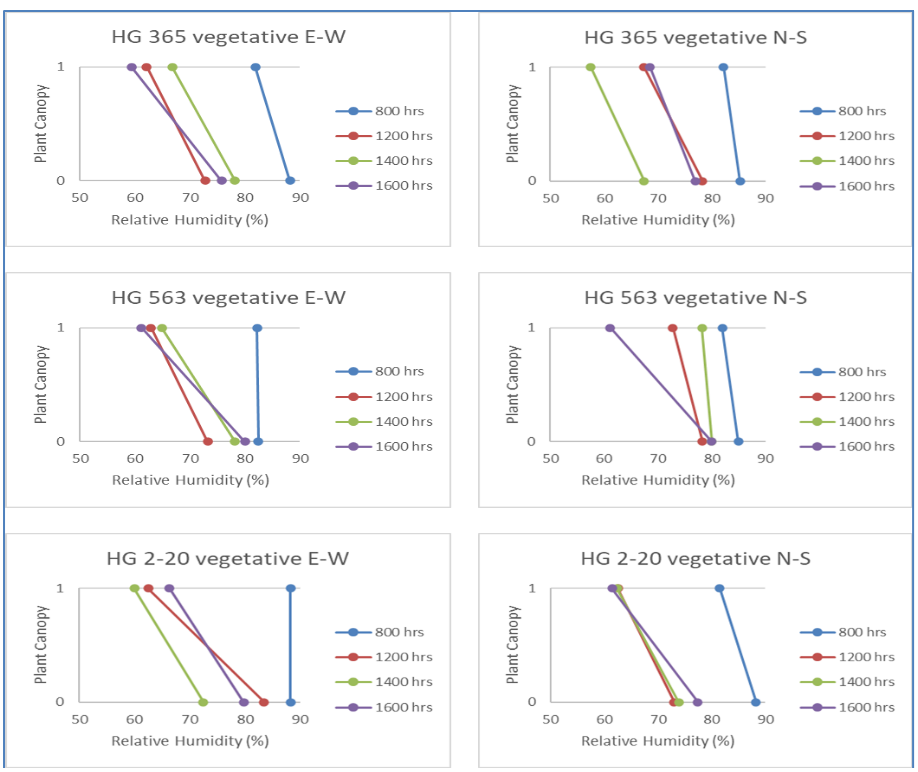

Fig. 10. Relative Humidity (%) profiles of different cluster bean cultivars in two crop row orientations at vegetative stage during *Kharif* 2021 (On Y-axis, "0", "0.5" and "1" indicate "Bottom", "Middle" and "Top" respectively, X-axis is temperature in °Celsius

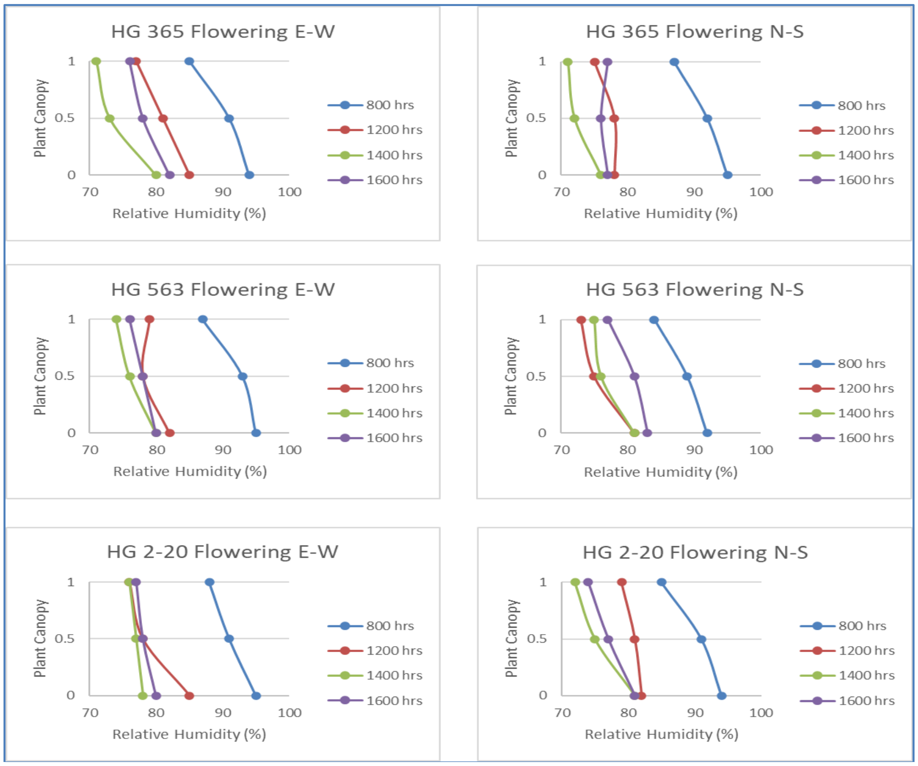

Fig. 11. Relative Humidity (%) profiles of different cluster bean cultivars in two crop row orientations at flowering stage during *Kharif* 2021 (On Y-axis, "0", "0.5" and "1" indicate "Bottom", "Middle" and "Top" respectively, X-axis is temperature in °Celsius

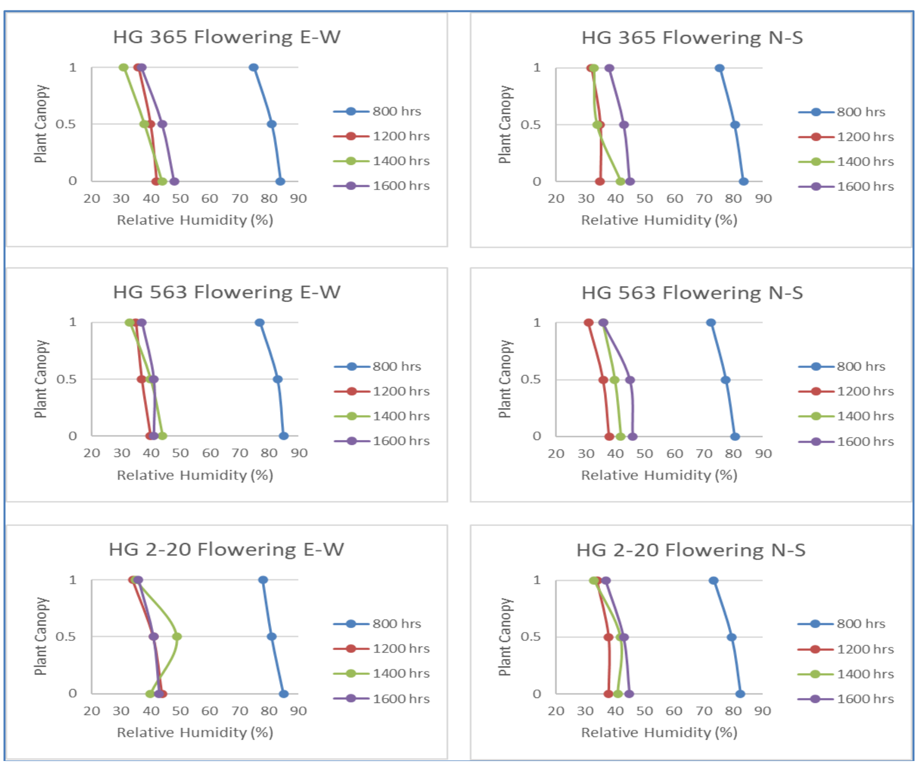

Fig. 12. Relative Humidity (%) profiles of different cluster bean cultivars in two crop row orientations at pod formation stage during *Kharif* 2021 (On Y-axis, "0", "0.5" and "1" indicate "Bottom", "Middle" and "Top" respectively, X-axis is temperature in °Celsius

TABLE 1

Seed yield and its attributes of cluster bean varieties under two crop row orientations during *Kharif* 2020

Treatments	Seed yield (q/ha)	Seeds per pod	Pods per plant	Test weight (g)
E-W	15.42	6.73	37.89	25.97
N-S	16.67	7.24	41.11	25.93
S.E. (m) ±	**0.14**	**0.25**	**0.96**	**0.11**
C.D. at 5%	**0.43**	**N/S**	**3.08**	**N/S**
HG 365	14.63	7.03	35.83	25.34
HG 563	15.88	6.90	40.00	26.18
HG 2-20	17.62	7.03	42.67	26.33
S.E. (m) ±	**0.17**	**0.31**	**1.18**	**0.14**
C.D. at 5%	**0.53**	**N/S**	**3.77**	**0.44**

TABLE 2

Seed yield and its attributes of cluster bean varieties under two crop row orientations during *Kharif* 2021

Treatments	Seed yield (q/ha)	Seeds per pod	Pods per plant	Test weight (g)
E-W	15.63	6.78	38.44	25.97
N-S	16.77	7.34	42.33	26.05
S.E. (m) ±	**0.11**	**0.21**	**1.06**	**0.21**
C.D. at 5%	**0.34**	**N/S**	**3.36**	**N/S**
HG 365	14.80	7.08	36.83	25.51
HG 563	16.10	6.98	40.83	26.24
HG 2-20	17.70	7.12	43.50	26.29
S.E. (m) ±	**0.13**	**0.25**	**1.30**	**0.26**
C.D. at 5%	**0.42**	**N/S**	**4.15**	**N/S**

cultivation. Morning time (0800 hrs) profiles were almost vertical. Afternoon time relative humidity profiles (1400 hrs) were lapsed which indicates a decrease in relative humidity with height. During night, the plants do not transpire and water vapour spreads in the whole of the canopy, while as the day progresses, the upper portion of the plant canopy does more transpiration and water vapour exchanged with the upper air, resulting in lower humidity at the top. The crop row orientation, East-West exhibited slightly higher middle level relative humidity in comparison to the North-South crop row orientation which again might be due to the aforementioned shading effect.

The variety HG 2-20 recorded higher relative humidity at the bottom canopy level during the flowering and pod formation stages compared to the other two varieties, consistently across both years of the study. This was also due to a much denser crop canopy and more branches in this variety.

During the vegetative stage, the difference in relative humidity between the top and bottom canopy levels was not as pronounced as in the flowering and pod formation stages. At the flowering stage, relative humidity at the top of the canopy was comparable to ambient levels, increased markedly at the middle canopy level, and showed a slight further increase at the bottom. In contrast, during the pod formation stage, relative humidity exhibited a consistent upward gradient from the top to the bottom of the canopy, with the highest values recorded at the bottom level.

3.3. *Seed yield and its attributes as affected by crop row orientation*

The North-South crop row orientation produced a significantly higher seed yield of 16.67 q/ha compared to 15.42 q/ha under the East-West orientation during 2020 (Table 1). A similar trend was observed in 2021, with the North-South orientation yielding 16.77 q/ha and the East-West orientation yielding 15.63 q/ha (Table 2). "During the first year, the variety HG 365 recorded the lowest seed yield (14.63 q/ha), while HG 2-20 produced the highest yield (17.62 q/ha). A similar trend was observed in the second year, with HG 365 and HG 2-20 yielding 14.80 q/ha and 17.70 q/ha, respectively.

The differences in the number of seeds per pod between the two crop row orientations were not statistically significant in either year of cultivation. Although the North-South orientation recorded slightly higher seeds per pod (7.24 in 2020 and 7.34 in 2021) compared to the East-West orientation (6.73 in 2020 and 6.78 in 2021), the variation was not significant. Similarly, the number of seeds per pod among the varieties was also statistically insignificant during both Kharif seasons. In 2020, HG 365 and HG 2-20 recorded 7.03 seeds per pod each, while HG 563 had 6.90. In 2021, HG 365 recorded 7.83, HG 563 had 6.98, and HG 2-20 recorded 7.18 seeds per pod, indicating only minor varietal differences.

Plants in the North-South oriented crop rows produced a higher number of pods per plant (41.11 in 2020 and 42.33 in 2021) compared to those sown in the East-West orientation (37.89 in 2020 and 38.44 in 2021). Among the varieties, HG 2-20 yielded the maximum number of pods per plant (42.67 in 2020 and 43.5 in 2021), followed by HG 563 (40.00 and 40.83), with HG 365 producing the least (35.83 and 36.83) across both seasons.

TABLE 3

Photosynthetically active radiation (%) intercepted by the canopy of cluster bean cultivars at different phenophases under two crop row orientations during *Kharif* 2020

Treatments	Vegetative	Flowering	Pod formation
E-W	50.2	91.0	89.5
N-S	50.7	91.7	89.7
S.E. (m) ±	**0.15**	**0.34**	**0.15**
C.D. at 5%	**0.46**	**N/S**	**N/S**
HG 365	49.7	89.4	89.1
HG 563	50.0	90.6	87.7
HG 2-20	51.5	94.2	91.9
S.E. (m) ±	**0.18**	**0.41**	**0.18**
C.D. at 5%	**0.57**	**1.31**	**0.58**

TABLE 4

Photosynthetically active radiation (%) intercepted by the canopy of cluster bean cultivars at different phenophases under two crop row orientations during *Kharif* 2021

Treatments	Vegetative	Flowering	Pod formation
E-W	50.4	91.7	89.6
N-S	50.9	92.3	90.0
S.E. (m) ±	**0.26**	**0.21**	**0.34**
C.D. at 5%	**N/S**	**0.66**	**N/S**
HG 365	50.0	90.2	89.2
HG 563	50.2	91.5	88.3
HG 2-20	51.8	94.4	92.0
S.E. (m) ±	**0.31**	**0.25**	**0.41**
C.D. at 5%	**0.99**	**0.81**	**1.30**

No significant differences were observed in the test weight of cluster bean seeds between the different row orientations (Tables 1 and 2). However, HG 365 produced slightly smaller seeds with lower test weights (25.34 g and 25.51 g) compared to HG 563 (26.18 g and 26.24 g) and HG 2-20 (26.33 g and 26.29 g).

The North-South crop row orientation produced a higher seed yield compared to the East-West orientation, primarily due to an increased number of pods per plant. However, crop row orientation did not significantly affect the number of seeds per pod or the test weight (1000-seed weight) of cluster bean. This yield advantage in the North-South orientation is likely attributable to greater light penetration at the middle and lower canopy levels, whereas the East-West orientation tends to create shading effects as rows shade one another. Similar observations regarding enhanced light penetration in North-South oriented crops were reported by Borger *et al*. (2010) in Western Australia.

The variety HG 2-20 yielded higher than HG 365 and HG 563, consistent with the findings of Premalakshmi *et al*. (2017) and Nampelli *et al*. (2020). The results from *Kharif* 2021 were slightly better than those from *Kharif* 2020, possibly due to marginally more favorable weather conditions during the second year of cultivation.

3.4. *Photosynthetically active radiation*

Radiation interception by cluster bean cultivars at various phenophases under two crop row orientation was computed and is presented in the Table 3 for *Kharif* 2020 and in Table 4 for *Kharif* 2021. PAR decreased with penetration in the canopy because of an increase in foliage (leaves). There was not much observable difference in PAR interception by crop canopy between two crop row orientations. Variety HG 2-20 intercepted maximum (51.5%, 94.2% and 91.9% during 2020 and 51.8%, 94.4% and 92% during 2021) of incident PAR at vegetative, flowering and pod formation respectively, followed by HG 365 and HG 563.

Both crop row orientations exhibited similar levels of photosynthetically active radiation (PAR) interception by their canopies. In the first year, only the vegetative stage showed higher PAR interception in the North-South orientation, whereas in the second year, the North-South orientation outperformed during the flowering stage. For the North-South orientation, the middle and lower canopy layers contributed more significantly to radiation interception. In contrast, in the East–West orientation, the upper leaves intercepted most of the PAR due to shading effects caused by successive rows. As expected, the cultivar with the densest canopy, HG 2-20, intercepted more incoming PAR compared to cultivars with less dense canopies in both years of cultivation. The percentage values of intercepted PAR across phenophases were consistent with observations reported by Khichar *et al*. (2012).

4. Conclusions

Based on the above-mentioned results, the following conclusions can be drawn:

(*i*) The difference between intercepted PAR by East-West or North-South crop row orientation was not significant, but HG 2-20 intercepted more PAR compared to HG 365 and HG 563 owing to its denser canopy.

(*ii*) North-South crop row orientation had a slightly higher middle canopy temperature and a corresponding slightly lower bottom canopy temperature. Variety HG 2-20 had lower bottom temperature and higher bottom relative humidity.

(*iii*) North-South crop row orientation yielded better than East-West crop row orientation in Cluster Bean. HG 2-20 produced the highest seed yield owing to its higher numbers of pods/plant when compared to HG 365 & HG 563.

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