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Effect of Micrometeorological Parameters on Growth and Yield of Brinjal (*Solanum melongena* L.) under Different Planting Windows

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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

An experiment was carried out at Faculty of Agriculture Department of Agricultural Meteorology Farm, Centre for Advanced Agricultural Meteorology, College of Agriculture, Pune during Kharif seasons of 2014 and 2015.The experiment was laid out in split plot design with three replications. The treatment comprised of three brinjal hybrids viz.,V1:Phule Arjun, V2: Krishna, V3: Panchganaga as main plot and four planting windows viz., P1: 31st MW (30 July-5 August), P2: 32ndMW (6-12August), P3:33rdMW (13-19 August) and P4: 34thMW (20-26 August) as sub plot treatments. In micrometeorological studies of the higher radiation absorptions and lower reflection was absorbed under hy. Phule Arjun as compared to hy. Krishana and hy Panchganga. The maximum Incident PAR (1270 u mol $m^{-2}s^{-1}$) Intercepted PAR (86.47u mol $m^{-2}s^{-1}$),Absorbed PAR (1094.4u mol $m^{-2}s^{-1}$) and Radiation use efficiency (2.43gmMJ m-2) was observed in hy .Phule

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Arjun. Cumulative GDD, HTU and PTU at the end of each growth stages showed that numerically higher requirement was observed in hy. Phule Arjun over hy. Krishana and hy. Panchganaga hybrids during both year 2014 and 2015 experimentation period. Whereas, the lowest canopy temperature was found in hy. Phule Arjun (29.0 ^{0}C) than rest of the brinjal hybrids. Canopy reflected PAR and transmitted PAR was higher in (191.54 and 188.62 µ mol m-^{2}s^{-1}) Panchganaga hybrids among the brinjal hybrids.

Keywords: Brinjal hybrids; kharif seasons; micrometeorological parameters; vegetable crop.

1. INTRODUCTION

Brinjal or egg plant (*Solanum melongena* Linnaeus) is from Solanaceae family belonging to genus *Solanum* and known as "King of vegetables". It is a native of India. It is an important vegetable crop grown throughout the country all the year round. Brinjal crop requires a long warm climate for its growth. Temperatures ranging between 25-32^{0}C are suitable for its cultivation. It does not prefer cool or frosty weather and requires silt loam to clay loam soil [1,2]. Determination of optimum planting windows is considered an important effort to have optimum yields and keep insect pest damage below economic threshold level (ETL) both quantitative and qualitative traits of crops depend on planting on the proper windows and growing season. In India higher brinjal quality Prolonged periods of low or high temperatures or sudden change in them adversely affect the insect development [3,4]. Different levels of humidity and rainfall, likewise, increase or reduce the population of certain insect pest species (Prasad & Logiswan, 1997). These factors affect the life cycle, propagation, and outbreaks of insects to such an extent that they are either compelled to adapt themselves to the changing climatic conditions and is extensively cultivated in Kharif and Rabi season. Timings of the management activities are crucial for the implementation of pest management tactics and consuming higher doses of pesticides [5-7]. High yield and quality of vegetables depends on high seed quality of improved cultivars, in addition to the optimum cultural practices [8,9]. Information on crop, its stages and the week by week weather during the crop season is essential for proper management of agriculture and better crop yield.

2. MATRIALS AND METHODS

The field experiment was conducted at Department of Agricultural Meteorology Farm, College of Agriculture, Pune during kharif seasons of 2014 and 2015. The experiment was conducted in a split plot design with three replications. The treatments were allotted randomly to each replication by keeping the gross plot size 4.5m x 3.75 m2 and net plot size 2.7 m x 2.7 m2with 90 x 75 cm spacing. There were twelve treatment combinations. The experiment was laid out in split plot design with three replications. The treatment comprised of three brinjal hybrids viz., V1: Phule Arjun V2: Krishna, V3:Panchganga as main plot and four planting windows viz., P1: 31MW (30 July- 3Aug), P2:32nd MW (6 Aug- 12 Aug),P3: 33rd MW (13Aug- 19 Aug) P4: 34th MW (20 Aug- 26 Aug) as sub plot treatments [10].

3. RESULTS AND DISCUSSION

The micrometeorological parameters have direct influence on crop growth, development and final yield of the crops. Therefore, micrometeorological studies *viz*., incident, intercepted, transmitted, reflected, canopy reflected, Soil reflected, absorbed and photosynthetically active radiation, light units were undertaken.

3.1 Incident Photosynthetically Active Radiation (IPAR)

3.1.1 Effect of hybrids

The values of *IPAR* recorded higher (1270 and 1373 µmol/m^2/s) in both the years i.e. 2014 and 2015 in hybrids Phule Arjun than other two hybrids *viz.* Krishna and Panchaganga. The *IPAR* increased with the age of the crop, leaf area and leaf area index increased up to 70 DAT and thereafter it declined till harvest.This was followed by hy.krishna and panchganga.The lowest (977 and 1033 µmol/m^2/s) *IPAR* values in both the years are recorded in hybrids Panchaganga.

3.1.2 Effect of planting windows

The *IPAR* increased as the age of the crop advances, leaf area and leaf area index upto 70 DAT and thereafter it declined till harvest.

Table 1. Incident PAR (μmolm^{-2}s^{-1}) as influenced periodically by different treatments in 2014 and 2015

Treatment	Incident PAR									
	14 DAT		28 DAT		42 DAT		56 DAT		70 DAT	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
A) Hybrids(H)										
V_1:Phule Arjun	1,066	1,175	1,223	1,335	1,270	1,373	1,201	1,322	1,108	1,209
V_2: Krishna	1,062	1,173	1,240	1,353	1,255	1,367	1,205	1,319	1,101	1,215
V_3: Panchganga	1,035	1,148	1,211	1,323	1,245	1,318	1,197	1,303	1,092	1,203
B) Planting Windows(D)										
P_1:31 MW (30 July– 5 August)	1,110	1,222	1,320	1,381	1,302	1,377	1,226	1,393	1,160	1,274
P_2:32 MW (6August 12August)	1,072	1,183	1,250	1,363	1,292	1,362	1,219	1,347	1,098	1,269
P_3:33MW (13August–19 August)	1,015	1,124	1,156	1,292	1,269	1,358	1,187	1,300	1,076	1,208
P_4:34MW(20August 2August)	1,008	1,121	1,143	1,265	1,164	1,275	1,178	1,213	1,067	1,078
General mean	1,053	1,164	1,220	1,330	1,257	1,347	1,202	1,314	1,100	1,208

Table 1. continued..

Treatments	84 DAT		120DAT		At harvest	
	2014	2015	2014	2015	2014	2015
A)Hybrids(H)						
V_1:Phule Arjun	980	1,057	1078	1100	932	934.59
V_2:Krishna	995	1,074	1095	1117	947	949.59
V_3:Panchganga	973	1,033	1054	1075	925	927.59
Planting Windows(D)						
P_1:31 MW (30July – 5 August)	1,005	1,119	1130	1141	957	959.59
P_2:32MW(6August–12August)	990	1,102	1113	1124	942	944.59
P_3:33MW(13August -19August	967	1,081	1092	1103	919	921.59
P_4:34MW(20August26August)	943	949	958	968	895	897.59
General mean	979	1,059	1073	1084	931	934

The *IPAR* value decreased due to decrease in leaf area and leaf area index owing to senescence of leaves. The 31st MW planting windows recorded higher values of *IPAR* (1377 and 1393 µmol/m^2/s) in both the years i.e. 2014 and 2015 and gradually decreased with delayed planting. At 34th MW recorded the lowest *IPAR* values (943 and 949 µmol/m^2/s) in both the years than rest of the planting windows.

3.2 Absorbed Photosynthetically Active Radiation (APAR)

3.2.1 Effect of hybrids

The values of *APAR* recorded higher (952.54 and 1029.75 µmol/m^2/**s**) in both the years i.e. 2014 and 2015 in hybrids Phule Arjun than other two hybrids *viz.,* Krishna and Panchaganga. The *APAR* increased with the age of the crop, leaf area and leaf area index increased up to 70 DAT and thereafter it declined till harvest. The lowest (729.75 and 774.75 µmol/m^2/s) *APAR* was observed in both the years i.e. 2014 and 2015 were recorded in hybrids Panchaganga than rest of the hybrids.

3.2.2 Effect of planting windows

The *APAR* increased with the age of the crop, leaf area and leaf area index increased up to 70 DAT and thereafter it declined till harvest. The *APAR* value decreased due to decrease in leaf area and leaf area index owing to senescence of leaves. The 31st MW planting windows recorded higher (919.50 and 1044.75 µmol/m^2/s) *APAR* in both the years i.e. 2014 and 2015 values of *APAR* and gradually decreased with delayed planting. At 34th MW recorded the lowest (707.25 and 711.75 µmol/m^2/s) in both years i.e. 2014 and 2015 of *APAR* than rest of the planting windows.

3.3 Intercepted Photosynthetically Active Radiation (IPAR)

3.3.1 Effect of hybrids

The values of *IPAR* recorded higher in *hy.* Phule Arjun (86.47 and 89.62 µmol/m^2/s) in both the years of 2014 and 2015 than other two hybrids *viz.,* Panchaganga and Krishna. The *IPAR* increased with the age of the crop, leaf area and leaf area index up to 56 DAT and thereafter it declined till harvest. The *IPAR* value decreased due to decrease in leaf area and leaf area index owing to senescence of leaf. The lowest *IPAR* values are recorded in hybrids Panchaganga (83.43 and 84.44 µmol/m^2/s) in both the years i.e. 2014 and 2015 than rest of the hybrids. This might be due to inherent genetic potential of Hybrids and poor growth of crops resulted in low leaf area index. These results are in corroborative with the findings of Sandhu and Horton (1978), Idso *et al.* (1981) and Jackson (1981).

3.3.2 Effect of planting windows

The *IPAR* increased with the age of the crop, leaf area and leaf area index up to 56 DAT and thereafter it declined till harvest. The *IPAR* value decreased due to decrease in leaf area and leaf area index owing to senescence of leaf. The 31st MW planting windows recorded higher values (87.13 and 91.81 µmol/m^2/s) of *IPAR* in both years i.e. 2014 and 2015 and gradually decreased with delayed planting. This might be due to rapid growth of crops, proper planting window and adequate soil moisture. Planting during 34th MW recorded the lowest (80.54 and 83.38 µmol/m^2/s) *IPAR* in both years than rest of the planting windows.

This might be due to poor growth of crops resulted in low leaf area index. Crop planted on the earliest windows attained the highest leaf area index (LAI), absorbed the largest amount of photosynthetically active radiation (PAR) and produced the highest total dry matter (DM).

3.4 Reflected Photosynthetically Active Radiation by Canopy + Soil (RPARcs)

3.4.1 Effect of hybrids

The values of *RPARcs* recorded higher (27.8 and 30.1 µmol/m^2/s) in hybrids Phule Arjun than other two hybrids *viz.,* Panchganga and Krishna. The *RPARcs* decreased with the age of the crop, leaf area and leaf area index increased up to 70 DAT and thereafter it declined till harvest. The lowest *RPARcs* values (21.3 and 22.6 µmol/m^2/s) were recorded in hybrids Panchganga than rest of the hybrids.

3.4.2 Effect of planting windows

The *RPARcs* increased with the age of the crop, leaf area and leaf area index increased up to 70 DAT and thereafter it declined till harvest. The *RPARcs* value decreased due to

decrease in leaf area and leaf area index owing to senescence of leaves. The 31st MW planting windows recorded higher values of (28.5 and 30.2 µmol/m^2/s) *RPARcs* and gradually decreased with delayed planting. At 34th MW recorded the lower values of (22.0 and 24.5 µmol/m^2/s) *RPARcs* than rest of the planting windowss. The high LAI persistence and PAR interception, coinciding with the vegetative phase appeared to be mainly responsible for the increased yield in early planting. Radiation use efficiency decreased as planting was delayed, but did not have much effect on dry matter accumulation in various phases nor on final yields. These results are in conformity with the findings of Okusanya (1978), Zieslin and Tsujita (1990).

3.5 Canopy Temperature

3.5.1 Effect of hybrids

Among the Hybrids the canopy temperature (^{0}C) remained more or less similar over total growing period of the crop during both the years of 2014 and 2015 .The hybrids Panchganga recorded the highest canopy temperature from 28 DAT (28.4 and 29.0^{o}C) to harvest (27.1 and 28.0 ^{o}C) as compared to hybrids Phule Arjun and Krishna. Among the hybrids, the canopy temperature (^{0}C) remained more or less similar over total growing period of the crop during both the years of 2014 and 2015. The Phule Arjun hybrids recorded significantly lower canopy temperature among the brinjal hybrids. Whereas, higher canopy temperature found in Panchganga than the rest of the brinjal hybrids. The canopy temperature found increasing trend with Panchganga followed by Krishna and Phule Arjun, respectively in 2014 and 2015. These results are in conformity with the findings of Singh *et al*. (1983) and Kadam *et al*. (1984).

3.5.2 Effect of planting windows

Data presented in Table below showed that during the year 2014 and 2015, canopy temperature (^{0}C) from 28 DAT to at harvest experienced by the crop showed increased with later planting windows (P1-31st MW to P4-34th MW) recorded the similar results that canopy temperature increased from emergence to harvesting with delay in planting windows. The lower values of canopy temperature recorded at 31st MW (P1) at 28 DAT (26.9 to 27.4) and at harvest (25.6 to 26.5). Which were gradually increased with delayed sowings in 34th MW (P4). The highest canopy temperature was recorded in 34th MW (P4) at 28 DAS (27.9 and 28.4) planting windows to till harvest (26.7 and 27.6) during both the years 2014 and 2015.

3.6 Transmitted Photosynthetically Active Radiation (TPAR)

3.6.1 Effect of hybrids

The data indicated that the highest *TPAR* was observed in hybrids Panchganga (316.63 and 318.88 µmol/m^2/s) in both the years i.e. 2014 and 2015 which was gradually decreased up to 56 DAT and thereafter increased gradually up to harvest. As leaf area and leaf *area* index increases the *TPAR* decreases. The lowest *TPAR* values (312.63 and 318.88 µmol/m^2/s) observed in hy.Phule Arjun of *IPAR* in both years the i.e. 2014 and 2015.

3.6.2 Effect of planting windows

The *TPAR* decrease with the age of the crop, leaf area and leaf area index up to 70 DAT and thereafter it increase till harvest. The *TPAR* value increased due to decrease in leaf area and leaf area index owing to senescence of leaves. The 34thMW planting windows recorded higher values (324.26 and 33.74 µmol/m^2/s) *TPAR* in both years i.e. 2014 and 2015 of *TPAR* and gradually decreased with early planting. This might be due to rapid growth of crops, proper planting window and adequate soil moisture. At 31th MW recorded the lowest (298.90 and 304.88 µmol/m^2/s) *TPAR* in both years i.e. 2014 and 2015 of *TPAR* than rest of Planting windows. This might be due to poor growth of crops resulted in low leaf area index.

3.7 Radiation Use Efficiency (RUE)

3.7.1 Effect of hybrids

The values of Radiation use efficiency were recorded higher (2.25 and 2.43 g MJ^{-1}m^{-2}) in both the years *i.e.* 2014 and 2015 in hybrids Phule Arjun than other two hybrids *viz.,* Krishna and Panchganaga. The lowest RUE values (1.85 and 1.86 g MJ^{-1} m^{-2}) in both the years i.e. 2014 and 2015 were recorded in hybrids Panchaganga.

Table 2. Absorbed PAR (μmolm^{-2}s^{-1}) as influenced periodically by different treatments in 2014 and 2015

Treatment	Accumulated absorbed PAR									
	14 DAT		28 DAT		42 DAT		56 DAT		70 DAT	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
A) Hybrids										
V_1:Phule Arjun	799.5	881.25	917.25	1001.25	952.50	1029.75	900.75	991.50	831.00	906.75
V_2: Krishna	796.50	879.75	930.00	1014.75	941.25	1025.25	903.75	989.25	825.75	911.25
V_3: Panchganga	776.2	861.00	908.25	992.25	933.75	988.50	897.75	977.25	819.00	902.25
B) Planting Windows										
P_1:31 MW (30July–5 August)	832.50	916.50	990.00	1035.75	976.5	1032.75	919.50	1044.75	870.00	955.50
P_2:32 MW (6August 12August)	804.00	887.25	937.50	1022.25	969.00	1021.50	914.25	1010.25	823.50	951.75
P_3:33MW (13August-19August)	761.25	843.00	867.00	969.00	951.75	1018.50	890.25	975.00	807.00	906.00
P_4:34M (20August 2August)	756.00	840.75	857.25	948.75	873.00	956.25	883.50	909.75	800.25	808.50
General mean	789.42	872.78	915.32	997.70	942.53	1010.35	901.39	985.39	825.21	906.00

Table 2. continued..

Treatments	84 DAT		120DAT		At harvest	
	2014	2015	2014	2015	2014	2015
A)Hybrids(H)						
V_1:Phule Arjun	735.00	792.75	808.61	824.78	700.94	525.71
V_2:Krishna	746.25	805.50	821.61	838.04	712.19	534.14
V_3:Panchganga	729.75	774.75	790.25	806.05	695.69	521.77
B) Planting Windows						
P_1:31 MW (30July – 5 August)	753.75	839.25	864.43	890.36	719.69	539.77
P_2:32MW(6August–12August)	742.50	826.50	851.30	876.83	708.44	531.33
P_3:33MW(13August -19August	725.25	810.75	835.07	860.12	691.19	518.39
P_4:34MW(20August26August)	707.25	711.75	733.10	755.10	673.19	504.89
General mean	734.25	794.46	820.97	845.60	700.19	525.14

Table 3. Intercepted PAR (μmolm^{-2}s^{-1}) as influenced periodically by different treatments in 2014 and 2015

Treatment	Accumulated Intercepted PAR															
	14 DAT		28 DAT		42 DAT		56 DAT		70 DAT		84 DAT		120 DAT		At final harvest	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
A)Hybrids (H)																
V_1:Phule Arjun	45.14	45.35	67.22	73.25	84.72	84.36	86.47	89.62	73.22	74.63	57.24	52.01	53.05	54.11	40.7	41.91
V_2: Krishna	33.34	28.11	60.12	60.41	76.39	76.86	83.43	84.44	69.26	68.35	52.61	50.43	51.44	52.47	39.1	40.33
V_3: Panchganga	31.23	34.5	63.41	60.95	74.28	74.87	84.38	85.48	67.18	69.01	51.72	60.53	61.74	62.98	49.2	50.43
B) Planting Windows (D)																
P_1:31 MW (30July–5 August)	57.48	59.3	72.29	74.28	83.1	85.91	87.13	91.81	75.41	76.06	58.85	61.41	62.64	63.89	50.1	51.31
P_2:32 MW (6August-12August)	42.05	44.09	66.31	66.63	79.52	80.68	85.52	88.42	71.59	74.83	55.47	57.92	59.08	60.26	46.6	47.82
P_3:33MW(13August –19August)	31.12	32.59	63.11	65.27	76.27	78.45	84.67	86.59	67.32	69.19	53.52	54.63	55.72	56.84	43.3	44.53
P_4:34M (20August 2August)	22.51	23.43	60.13	62.25	72.98	73.42	80.54	83.38	65.12	67.21	48.31	51.12	52.14	53.19	39.8	41.02
General mean	38.29	39.85	65.46	67.11	77.97	79.62	84.47	87.55	69.86	71.82	54.04	56.27	57.40	58.54	44.9	46.17

Table 4. Reflected PAR (μmolm^{-2}s^{-1}) as influenced periodically different by treatments in 2014 and 2015

Treatment	14 DAT		28 DAT		42 DAT		56 DAT		70 DAT		84 DAT		120 DAT		At final harvest	
	2014	2015	2014	2015	2014	2015	2014	2014	2015	2015	2014	2015	2014	2015	2014	2015
A)Hybrids(H)																
V_1 :Phule Arjun	23.35	25.73	26.8	29.2	27.8	30.1	26.3	29.0	24.3	26.5	21.5	23.2	23.6	24.0	20.47	15.35
V_2: Krishna	23.26	25.69	27.2	29.6	27.5	29.9	26.4	28.9	24.1	26.6	21.8	23.5	23.9	24.4	20.80	15.60
V_3: Panchganga	22.67	25.14	26.5	28.9	27.2	28.8	26.2	28.54	23.9	26.3	21.3	22.6	23.0	23.5	20.31	15.24
B) Planting Windows(D)																
P_1:31 MW (30 July– 5 August)	24.31	26.76	28.9	30.2	28.5	30.1	26.8	30.51	25.4	27.9	22.0	24.5	25.0	25.5	21.02	15.76
P_2:32 MW (6August 12August)	23.48	25.91	27.3	29.8	28.2	29.8	26.7	29.50	24.0	27.7	21.6	24.1	24.6	25.1	20.69	15.51
P_3:33MW (13August –19August)	22.23	24.62	25.3	28.2	27.7	29.7	26.0	28.47	23.5	26.4	21.1	23.6	24.1	24.6	20.18	15.14
P_4:34M (20August 2August)	22.08	24.55	25.0	27.7	25.4	27.9	25.8	26.56	23.3	23.6	20.6	20.7	21.2	21.6	19.66	14.74
General mean	23.05	25.49	26.7	29.1	27.5	29.5	26.3	28.77	24.1	26.4	21.4	23.2	23.7	24.2	20.45	15.33

Table 5. Canopy temperature (^{0}C) regime of brinjal as influenced periodically by different treatments in 2014 and 2015

Treatment	14 DAT		28 DAT		42 DAT		56 DAT		70 DAT		84 DAT		120 DAT		At final harvest	
	2014	2015	2014	2015	2014	2015	2014	2014	2015	2015	2014	2015	2014	2015	2014	2015
A)Hybrids(H)																
V_1 :Phule Arjun	18.1	19.3	18.7	20.0	18.3	19.5	20.3	21.6	21.9	23.1	24.3	25.6	26.1	26.6	24.9	25.8
V_2: Krishna	19.0	20.2	19.6	20.9	18.7	19.9	21.3	22.6	22.5	24.4	25.5	26.8	27.3	27.9	26.1	26.9
V_3: Panchganga	19.2	20.5	20.6	21.9	20.4	21.7	22.6	23.9	24.3	25.6	26.6	27.8	28.4	29.0	27.1	28.0
B) Planting Windows(D)																
P_1:31 MW (30 July– 5 August)	18.0	19.4	19.8	21.1	19.0	20.2	20.4	23.7	23.3	24.1	25.1	26.3	26.9	27.4	25.6	26.5
P_2:32 MW (6August 12August)	19.1	20.4	20.5	21.8	20.3	21.6	21.6	23.9	23.3	24.7	26.3	27.6	28.1	28.7	26.9	27.8
P_3:33MW (13August –19 August)	19.0	20.3	19.6	20.9	19.3	20.5	21.9	23.2	23.1	24.5	26.2	27.5	28.0	28.6	26.8	27.6
P_4:34M (20August 2August)	18.3	19.6	19.7	21.7	19.4	20.7	21.8	24.3	23.0	25.1	26.2	27.3	27.9	28.4	26.7	27.6
General mean	18.8	20.1	19.8	21.2	19.5	20.7	21.7	23.5	23.1	24.6	25.7	26.9	27.5	28.1	26.3	27.2

Table 6. Transmitted PAR (µmolm^{-2}s^{-1}) influenced periodically different by treatments in 2014 and 2015

Treatment	Accumulated Transmitted PAR									
	14 DAT		28 DAT		42 DAT		56 DAT		70 DAT	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
A) Hybrids(H)										
V_1 :Phule Arjun	305.11	337.91	355.13	387.31	272.07	289.38	188.96	206.03	320.62	352.50
V_2: Krishna	309.06	341.57	359.37	391.69	273.15	294.71	189.59	207.29	321.93	354.25
V_3: Panchganga	309.65	341.86	356.89	389.06	274.78	295.37	189.28	207.53	322.96	353.38
B) Planting Windows(D)										
P_1:31 MW (30 July– 5 August)	301.62	334.38	346.27	380.54	263.25	285.76	187.35	199.05	316.97	334.47
P_2:32 MW (6August 12August)	310.98	343.44	361.92	394.88	277.17	295.22	190.58	209.61	321.51	362.41
P_3:33MW (13August –19 August)	302.64	334.82	348.17	384.49	274.67	294.79	188.06	205.91	318.29	353.49
P_4:34M (20August 2August)	316.53	349.15	372.16	397.51	278.26	296.85	191.13	213.23	330.57	363.14
General mean	307.94	340.45	357.13	389.35	273.33	293.15	189.28	206.95	321.84	353.38

Table 6. continued….

Treatments	84 DAT		120DAT		At final harvest	
	2014	2015	2014	2015	2014	2015
A)Hybrids(H)						
V_1:Phule Arjun	285.08	306.50	312.63	318.88	272.07	289.38
V_2:Krishna	288.30	312.50	318.75	325.13	273.15	294.71
V_3:Panchganga	286.10	310.01	316.21	322.53	274.78	295.37
B) Planting Windows(D)						
P_1:31 MW (30July – 5 August)	281.63	293.04	298.90	304.88	263.25	285.76
P_2:32MW(6August–12August)	288.50	315.41	321.72	328.15	277.17	295.22
P_3:33MW(13August -19August	285.14	312.34	318.59	324.96	274.67	294.79
P_4:34MW(20August26August)	290.70	317.90	324.26	330.74	278.26	296.85

Table 7. Radiation use efficiency ($gmMJ^{-1}m^{-2}$) of brinjal influenced periodically different by treatments in 2014 and 2015

Treatment	14 DAT		28 DAT		42 DAT		56 DAT		70 DAT		84 DAT		120 DAT		At final harvest	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
A)Hybrids(H)																
V_1 :Phule Arjun	0.18	0.18	0.51	0.49	0.50	0.48	2.25	2.43	2.39	2.25	2.12	1.98	2.16	2.12	1.85	1.76
V_2: Krishna	0.10	0.12	0.21	0.24	0.41	0.41	2.18	2.33	2.27	2.14	1.94	1.82	1.98	1.94	1.78	1.69
V_3: Panchganga	0.06	0.08	0.15	0.18	0.35	0.35	2.13	2.26	2.15	2.03	1.82	1.72	1.86	1.82	1.70	1.64
B)Planting windows(D)																
P_1:31 MW (30 July– 5 August)	0.12	0.13	0.32	0.34	0.46	0.45	2.28	2.46	2.35	2.21	2.01	1.85	2.05	1.95	1.83	1.76
P_2:32 MW (6August -12August)	0.12	0.13	0.30	0.31	0.44	0.43	2.23	2.41	2.25	2.07	1.93	1.80	1.97	1.87	1.77	1.70
P_3:33MW (13August -19 August)	0.12	0.13	0.29	0.30	0.42	0.41	2.12	2.29	2.26	2.11	1.91	1.79	1.95	1.85	1.76	1.68
P_4:34M(20August -26August)	0.09	0.11	0.26	0.27	0.37	0.37	2.12	2.18	2.22	2.19	1.98	1.91	2.02	1.92	1.74	1.64
General mean	0.11	0.13	0.29	0.31	0.42	0.41	2.19	2.34	2.27	2.14	1.96	1.84	2.00	1.90	1.78	1.70

Table 8. Cumulative growing degree days (GDD) of brinjal as influenced stage wise different by treatments in 2014 and 2015

Treatment	EM		VG		50% FL		First FR		At final harvest	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
A) Hybrids(H)										
V_1 :Phule Arjun	59.6	72.3	481.76	478.3	575.5	568.65	681.66	645.7	1178.43	1183.7
V_2: Krishna	47.56	47.63	470.28	467.48	552.18	535.01	623.38	602.55	1166.28	1170.42
V_3: Panchganga	35.41	46.13	447.2	444.48	540.26	512.55	599.13	568.65	1154.11	1157.22
B) Planting Windows(D)										
P_1:31 MW (30 July– 5 August)	53.75	61	46.45	484.6	525.5	597.55	631.8	658.6	1135.55	1183.2
P_2:32 MW (6August 12August)	45.25	59.4	453.3	464.9	530.85	554.53	624.3	641.35	1143.25	1161.85
P_3:33MW (13August –19 August)	39.1	50.4	457.5	471.85	526.45	543.25	616.4	621	1128.95	1152.1
P_4:34M (20August 2August)	37.85	38.65	452.2	469.65	512.45	539.05	611.05	611.4	1129.65	1143.4
General mean	45.50	53.64	401.24	468.75	537.60	550.08	626.82	621.32	1148.03	1164.56

Table 9. Cumulative Heliothermal units (HTU) of brinjal as influenced stage wise by different treatments in 2014 and 2015

Treatment	EM		VG		50% FL		First FR		At final harvest	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
A) Hybrids(H)										
V_1 :Phule Arjun	249.97	351.86	1544.45	3539.83	1893.69	4357.69	2142.17	4993.37	5376.94	9190.09
V_2: Krishna	161.48	195.88	1450.24	3247.27	1698.43	4047.63	1893.69	4555.53	5282.36	9286.87
V_3: Panchganga	15188.	271.31	1508.33	3435.54	1763.81	4164.83	2014.88	4902.32	5370.95	9086.14
B) Planting Windows										
P_1:31 MW (30 July– 5 August)	251.24	34.785	1628.53	1982.23	1930.74	2767.46	2333.667	4904.23	4899.03	9970.4
P_2:32 MW (6August 12August)	145.055	344.27	1277.85	3927.96	1673.78	4770.45	1852.04	5303.45	5027.52	10154.52
P_3:33MW (13August –19 August)	93.96	411.98	1553.68	4044.66	1684.69	4629.4	1915.68	5318.79	5587.88	10145.44
P_4:34M (20August 2August)	184.64	100.255	1353.01	3658.41	1695.25	4177.76	2058.23	3223.48	5989.48	6877.1
General mean	178.26	244.33	1473.73	3405.13	1762.91	4130.75	2030.05	4743.02	5362.02	9244.37

Table 10. Heat use efficiency ($gmm^{-2}day^{-1}$) of brinjal influenced periodically by different treatments in 2014 and 2015

Treatment	14 DAT		28 DAT		42 DAT		56 DAT		70 DAT		84 DAT		120 DAT		At final harvest	
	2014	2015	2014	2015	2014	2015	2014	2014	2015	2015	2014	2015	2014	2015	2014	2015
A)Hybrids (H)																
V_1 :Phule Arjun	0.01	0.02	0.36	0.36	0.48	0.50	1.10	1.09	1.48	1.48	1.80	1.83	1.84	1.85	1.74	1.76
V_2: Krishna	0.00	0.01	0.10	0.13	0.24	0.27	0.82	0.84	1.19	1.16	1.47	1.50	1.56	1.56	1.45	1.44
V_3: Panchganga	0.01	0.01	0.13	0.16	0.29	0.32	0.87	0.91	1.26	1.26	1.58	1.61	1.66	1.67	1.56	1.55
B)Planting windows(D)																
P_1:31 MW (30 July– 5 August)	0.01	0.01	0.23	0.25	0.39	0.42	1.04	1.02	1.40	1.39	1.70	1.71	1.83	1.79	1.68	1.68
P_2:32 MW (6August 12August)	0.01	0.01	0.20	0.22	0.35	0.38	0.95	0.96	1.33	1.31	1.61	1.62	1.72	1.71	1.59	1.59
P_3:33MW (13Augu2st –19August)	0.01	0.01	0.19	0.21	0.33	0.35	0.92	0.93	1.30	1.28	1.57	1.58	1.67	1.66	1.56	1.55
P_4:34M (20August 2August)	0.01	0.01	0.17	0.19	0.29	0.31	0.86	0.87	1.21	1.24	1.53	1.54	1.58	1.60	1.48	1.51
General mean	0.01	0.01	0.20	0.22	0.34	0.36	0.94	0.94	1.31	1.30	1.60	1.61	1.69	1.69	1.58	1.58

3.7.2 Effect of planting windows

The planting windows at 31st MW recorded higher values of (2.28 and 2.46 g $MJ^{-1}m^{-2}$) radiation use efficiency and gradually decreased with delayed planting. The radiation use efficiency increased periodically from 28 DAT to 70 DAT. After 70 DAT, radiation use efficiency was declined up to final harvest. The planting windows at 34 thMW recorded the lowest values of (2.02 and 1.92 g $MJ^{-1}m^{-2}$ radiation use efficiency than rest of the planting windows.

3.8 Determination of Growing Degree Days (GDD)

3.8.1 Effect of hybrids

The GDD in different hybrids varied from 35.41 to 72.3^{0}C for emergence, 444.48 to 481.76^{0}C days for vegetative growth, 512 to 575^{0}C for 50 % flowering, 568.65 to 681.66^{0}C days for first fruit setting and 1154.11^{0}C to 1183.7^{0}C days for final harvest. The highest values of GDD were recorded in hybrids Phule Arjun and the lowest values of GDD were recorded in hybrids Panchganaga.

3.8.2 Effect of planting windows

The GDD in different planting windows varied from 37.85 to 61^{0}C for emergence, 452.2 to 484.6^{0}C days for vegetative growth, 512.45 to 597.55^{0}C for 50 % flowering, 611.05 to 658.66^{0}C days for first fruit setting and 1128.85^{0}C to 1183.2^{0}C days for final harvest. The highest values of GDD were recorded in 31st MW planting windows and the lowest values of GDD were recorded in 34th MW planting windows. This might be due to delayed planting completed each phenophases earlier than the late planted crop.

3.9 Determination of Heliothermal Units (HTU)

3.9.1 Effect of hybrids

The HTU in different hybrids varies from (151. 88 to 351.86) units for emergence, (1450.24 to 3539.83) units for vegetative growth, (1698.43 to 4357) units for 50 % flowering, (1893.69 to 4993.37) units for first fruit setting and (5282.36 to 9286.87) units for final harvest. The highest values of HTU were recorded in hybrids Phule Arjun and the lowest values of HTU were recorded in hybrids Panchganaga.

3.9.2 Effect of planting windows

The HTU in different planting windows varies from (93.96 to 411.98) for emergence, (1277.85 to 4044.66) units for vegetative growth, (1673.78 to 4770.45) units for 50 % flowering, (1852.04 to 3223.48) units for first fruit setting and (4899.03 to 10154.52) units for final harvest. The highest values of HTU were recorded at 31st MW planting window and the lowest values of HTU were recorded at 34thMW planting window. This might be due to delayed planting completed each phenophases earlier than the late planted crop.

3.10 Heat Use Efficiency (HUE)

3.10.1 Effect of hybrids

The values of heat use efficiency were recorded higher in (1.84 and1.85 gm m^{-2} day^{-1}) hybrids Phule Arjun than other two Hybrids *viz.,* Krishna and Panchganaga. The lowest heat use efficiency values were recorded in (1.66 and 1.67 gm m^{-2} day^{-1}) hybrids Panchganga.

3.10.2 Effect of planting windows

The 31thMW planting windows recorded higher values of (1.83 and 1.79 gm m^{-2} day^{-1}) heat use efficiency and gradually decreased with delayed planting. The heat use efficiency increased periodically from 28 DAT to 70 DAT. After 70 DAT, heat use efficiency was declined up to final harvest. The planting windows at 34thMW lower values recorded (1.58 and 1.60 gm m^{-2} day^{-1}) in the heat use efficiency than rest of the planting windows.

4. CONCLUSION

High yield and quality of vegetables depends on high seed quality of improved cultivars, in addition to the optimum cultural practices. In micrometeorological studies of the higher radiation absorptions and lower reflection was absorbed under hy. Phule Arjun as compared to hy.Krishana and hy Panchganga.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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