Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(6): 2053-2056
Received: 25-08-2020
Accepted: 05-10-2020

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Effect of weather parameters on growth and yield of pearl millet

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Abstract
The experiment entitled, "Effect of Weather Parameters on Growth and Yield of Pearl Millet" was conducted in split plot design with three replications during *kharif* 2018, at Mulegaon Agricultural Farm, Zonal Agricultural Research Station, Solapur. The Sowing of crop during 30th MW significantly absorbed more photosynthetically active radiation (APAR), Heat use efficiency (HUE), light use efficiency (LUE) during both the period of experimentation correspondingly in this MW it produced more grain, fodder and biological yields over the crop sown in 26th MW. The crop sown early in 26th MW absorbed significantly less photosynthetically active radiation and accumulated less growing degree day (GDD) resulted in production of the lowest light use efficiency and heat use efficiency (HUE).

Keywords: Weather parameters, pearl millet, Mulegaon agricultural farm

Introduction
Last few decades, there has been an increasing of the importance of millets in India, major cereals which are grown on soils supplied with large quantity of fertilizers, irrigation and pesticide inputs have attained yield plateau. Millets have potentiality of contributing to increased food production, both in developing and developed countries. Millets are one of the cereals asides the major wheat, rice, and maize. Millets are major food sources for millions of people, especially those who live in hot, dry areas of the world. In contrast, millet is the major source of energy and protein for millions of people in Africa. It has been reported that millet has many nutritious and medical functions (Yang *et al*. 2001) [15]. They are grown mostly in marginal areas under agricultural conditions in which major cereals fail to give substantial yields. Pearl millet (*Pennisetum glaucum* L.Br.). Popularly known as Bajra, cattle millet, bulrush millet belongs to the grass family or gramineae. In the world, its rank sixth followed by rice, wheat, corn, barley and sorghum (Anonymous, 2010) [2]. However, in India, it is fourth most important cereal crop after rice, wheat and sorghum. It has the greatest potential among all the millets. In India, annual planting area under pearl millet is 9.4 million hectares producing nearly 10.1million tonns of grains. The Pearl millet growing countries are India, China, Nigeria, Pakistan, Sudan, Egypt, Arabia, and Russia. India is the largest producer of Pearl millet in the world. In India major producing state are Rajasthan (46%), Maharashtra (19%), Gujarat (11%), Uttar Pradesh (8%) and Haryana (6%). Sowing time is the most important non-monetary input influencing crop yield. Sowing at optimum time improves the productivity by providing suitable environment at all the growth stages. Upadhyay *et al.* (2001) [15] have reported higher grain yield of summer pearl millet when sown on 15 march and found reduction in grain yield with delay in sowing. Identifying suitable time of sowing for pearl millet during summer is important to have proper growth and development of plants, save the crop from early monsoon showers and timely vacate the field for succeeding *kharif* crop. Keeping in view of the importance the study was aimed to investigate influence of weather parameters on pearl millet (*Pennisetum glaucum* L.) varieties under in scarcity zone of Maharashtra.

Materials and Methods
The field experiment was conducted during *kharif* season, 2018 at Mulegaon Farm, Zonal Agricultural Research Station, Solapur, Maharashtra State, (India), geographically the campus of Mulegaon Agricultural Farm is situated on 17º41' N latitude and 75º56'E longitude. The altitude is about 483.6 M above mean sea level. The soil of experimental field was clay loam in texture with moderately alkaline in reaction (pH 7.4). The soil was low in available nitrogen(128 kg ha^{-1}), medium in available phosphorus (14 kg ha^{-1}) and high in available potassium (399 kg ha^{-1}), while low in organic carbon content (0.35%).

Agroclimatically, the Mulegaon Agricultural Farm, Zonal Agricultural Research Station, Solapur comes under dry (Arid and Semi-arid) zone. The maximum temperature being 40 ^{0}C or more. The highest temperature ever recorded was 46 ^{0}C in May during 1988. The monsoon lasts from June to the end of September, with moderate rainfall winter begins in November and lasts until end of February, with the temperatures occasionally dropping below 10 ^{0}C.The data revealed that during crop growth period, the annual maximum and minimum temperature ranged between 25.0 to 43.2 ^{0}C and 7.3 to 27.1 ^{0}C respectively. During the *kharif* season, the maximum temperature ranged between 29.0 to 40.8 ^{0}C with an average of 34.7 ^{0}C, whereas, the minimum temperature ranged between 18.0 to 26.2 ^{0}C.The pan evaporation ranged between 1.8 to 12.8 mm with an average of 7.4 mm. The wind speed ranged between 2.1 to 18.3 km ph^{-1} with an average of 9.7kmh^{-1}. In case of BSS which was ranged between 0.0 to 12.1 hrs with an average of 5.2 hrs. The morning RH ranged between 67 to 98 per cent with an average of 80per cent and the afternoon RH ranged between 24 to 95 per cent during the crop growth period.

Experimental details

The experiment was laid out in split plot design with three replications. Nine treatment combinations were formed considering main plot treatments comprise three sowing dates and three sub-plot treatments of three cultivars. The details are listed below,

Main plot treatment: Sowing times (3)

1. S_1 : 26MW (26th June – 01stJuly)
2. S_2 : 30MW (23rdJuly – 29thJuly)
3. S_3 : 33MW (13th Aug – 19th Aug)

Sub plot treatment: Cultivars (3)

1. V_1 : ICTP-8203
2. V_2 : Dhanshakti
3. V_3 : Parbhani Sampada

Measurement of absorbed radiations

a. APAR = (PAR + RPAR) – (TPAR + RPAR)
b. Interscepted PAR = Incident PAR – Transmitted PAR
c. IPAR = PARO – TPAR µ mol m^{-2} s^{-1}

PAR measured by an instrument line quantum sensor for measuring transmitted radiation (monteith and unsworth), the sensor was in the crop while for measuring

Estimation of light use efficiency (LUE)

Incident radiation = Transmitted radiation + Reflected Radiation + Absorbed radiation

Therefore,

Absorbed radiation = Incident radiation – (Transmitted radiation + Reflected radiation)

With the help of cumulative absorbed radiation and vegetative plant, itis posible to estímate the light use efficiency of plant.
Light use efficiency was determined as,

$$LUE = \frac{\text{Amount of green dry matter produced } (g/m^{-2})}{\text{Amount of cumulutive light absorbed } (MJ/m^{-2})}$$

Result and Discussions

Absorbed photosynthetically active radiation (APAR)

The data in respect of absorbed photosynthetically active radiation (APAR) in per cent as influenced periodically by different treatments are presented in Table 1. The mean absorbed photosynthetically active radiation (APAR) values were increased with advanced maintain crop age and reached maximum at 72 DAS (84.54 per cent). Thereafter, absorbed photosynthetically active radiation (APAR) values were decreased due to crop senescence.

Effect of sowing environment

Sowing of crop in 30th MW increased absorbed photosynthetic active radiation (APAR) values as compared to early sowing in 26th MW and delayed sowing in 33rd MW during initial crop growth period at 28, 42 and 56 DAS during the period of experimentation. It was observed that sowing of pearl millet in 33^{ed} MW absorbed more photosynthetically active radiation (PAR) (84.54 per cent) than early sown pearl millet in 26th MW (78.61per cent) on 72 DAS. Further, it was noticed that the lowest values of photosynthetically active radiation (PAR) were noticed in early sown crop in 26th MW (12.63per cent) on 28 DAS. The crop sown in 30th MW absorbed the highest photosynthetically active radiation (PAR) from 42 to 72 DAS, onwards owing to production of maximum leaf area. Further, it was observed that crop sown delayed in 33rd MW also absorbed more photosynthetically active radiation (PAR) than early sown crop in 26th MW on 42, 56 and 72 DAS. It was significantly the lowest under delayed sown crop in 33rd MW on these days.

Effect of cultivars

Among cultivars Dhanashakti absorbed more photosynthetically active radiation on 72 DAS in all sowing windows, i.e. 26th, 30th, and 33rd MW. It was also observed that the lowest values of absorbed photosynthetically active radiation is lowest in ICTP-8203 and Parbhani Sampada (11.31 per cent) and (9.89per cent) when the crop was sown on 26th MW.

Light use efficiency (LUE) (g/µ mole m^{-2} s^{-1})

Light use efficiency (LUE) is the relationship between dry matter production and absorbed photosynthetically active radiation (APAR) by the crop. The many indices are available for measuring the growth and yield of crop. However, light use efficiency (LUE) is the reliable index of measuring growth, development and yield of crop.

The data regarding light use efficiency (LUE) as influenced periodically by different treatments are presented in Table 2.During the initial period of crop growth the mean light use efficiency (LUE) values were very low (0.5, 0.6 and 0.5 g µ mole m^{-2} sec^{-1}) on 28 DAS when the crop was sown on 26th MW. These values were increased with advancement of crop age and reached maximum (3.5 g µ mole m^{-2} sec^{-1}) on 72 DAS when the crop was sown on 30th MW owing to maximum leaf area production which resulted in absorption of maximum photosynthetically active radiation (PAR) and ultimately, maximum light use efficiency (LUE). The light use efficiency (LUE) values were declined thereafter, due to senescence of crop.

Effect of sowing windows

The sowing of crop in 30th MW produced highest light use efficiency (LUE) whereas, crop sown in 26th MW produced lowest light use efficiency (LUE) values at all the days of

observations during the period of experimentation owing to absorption of maximum photosynthetically active radiation (PAR), production of maximum leaf area and dry matter by the crop sown in 30th MW whereas, absorption of less photosynthetically active radiation (PAR) and production of less leaf area and dry matter by the early sown crop in 26th MW.
Further, it was observed that the crop sown delayed in 33rd MW also produced more light use efficiency (LUE) than crop sown in 26th MW at all the days of observations during period of experimentation, because of favourable microclimatic situation under delayed sown crop might have produced more leaf area and dry matter and consequently increased light use efficiency (LUE).

Effect of cultivars
Further, it was observed that the cultivar Dhanashakti produced more light use efficiency (LUE) than Parbhani Sampada and ICTP-8203 when the crop was sown on 30th MW at all the days of observations during period of experimentation. Because of favourable microclimatic situation under dealyd sown crop might have produced more leaf area and dry matter and consequently increased light use efficiency (LUE).
The maximum light use efficiency was produced in all cultivars on 72 DAS in all sowing window. i.e. 26th, 30th and 33rd MW. These results are inconformity with findings of Williams's *et al*. (1965) [14], Marshall and Willey (1983) [8], Andrade *et al*. (1993) [1].

Yield
The mean grain, fodder and biological yields and harvest index were 1840.26, 3454.85, 5102.11 kg ha^{-1} and 3587 per cent respectively, during the period of experimentation are presented in Table 3.

Effect of sowing windows
Kharif pearl millet sown in 30th MW significantly increased grain (1990.33kg ha^{-1}), fodder (3688.56kg ha^{-1}) and biological yields (5485.89kg ha^{-1}) as compared to early crop sown in 26th MW and late sown in 33rd MW during the period of experimentation. The crop sown in 33rd MW significantly decreased grain (1835.22 kg ha^{-1}), fodder (3506.33 kg ha^{-1}) and biological (5148.56kg ha^{-1}) yields as compared to crop sown in 30th MW. The lowest grain (1695.22kg ha^{-1}), fodder (3169.67 kg ha^{-1}) and biological (4671.89kg ha^{-1}) yields were recorded when the crop was sown early in 26th MW. The moisture availability at critical crop growth stages significantly increased micro meteorological parameters *viz.*, absorbed photosynthetically active radiation (APAR), light use efficiency (LUE), significant increase in growth attributes *viz.*, plant height, number of effective tillers, leaf area and dry matter production $plant^{-1}$ and important yield contributing characters *viz.*, earhead length and girth, earhead weight $plant^{-1}$, grain weight $earhead^{-1}$ and 1000 grain weight resulted in significant increase in grain and stover yields.
The significant reduction in grain and fodder yields was observed when the crop was sown early in 26th MW and late sown in 33rd was mainly attributed to significant reduction in micro meteorological parameters, physiological aspects, growth attributes and yield contributing characters. Similar findings were also reported by Tomar *et al.* (1976) [12] and Kaushik and Gautam (1984) [6].

Effect of cultivars
Among the cultivars, Dhanashakti produced significantly the highest grain (1785.6 kg ha^{-1}), fodder (3514.4 kg ha^{-1}) and biological yields (5300kg ha^{-1}) was recorded. The yields was significantly decreased in cultivar Parabhani Sampada (1682.6 kg ha^{-1}), fodder (3235.6 kg ha^{-1}) and biological yields (4918.1 kg ha^{-1}). Among cultivars ICTP-8203 significantly produced the lowest grain (1473.7 kg ha^{-1}), fodder (3056.6 kg ha^{-1}) and biological yield (4509.2 kg ha^{-1}).

Effect of interaction
The grain, fodder and biological yields and harvest index were not significantly affected due to interaction effects between sowing windows and cultivar during the period of experiment.

Table 1: Mean absorbed photosynthetically active radiation (APAR) in (Percent) as affected periodically by different treatment

Treatment		Mean absorbed photosynthetically active radiation (APAR) in (Percent)					
		Days after sowing					
Sowing window	Cultivar	28	42	56	72	84	At harvest
S_1: 26 MW (26th June – 01st July)	V_1 : ICTP-8203	11.11	43.08	63.06	73.07	54.84	34.81
	V_2 : Dhanashakti	13.85	48.02	72.64	79.83	65.07	40.16
	V_3 : Parbhani Sampada	12.53	45.84	66.53	76.90	62.03	39.43
S_2: 30 MW (23rd July – 29th July)	V_1 : ICTP-8203	13.27	47.14	73.13	80.27	61.05	40.12
	V_2 : Dhanashakti	16.45	52.58	79.39	85.76	70.54	44.64
	V_3 : Parbhani Sampada	15.17	49.75	77.06	82.32	65.42	43.17
S_3 : 33 MW (13th Aug. – 19th Aug.)	V_1 : ICTP-8203	12.15	44.50	65.54	75.06	57.13	35.45
	V_2 : Dhanashakti	15.14	49.45	74.78	82.78	66.46	42.82
	V_3 : Parbhani Sampada	12.98	47.54	69.60	79.48	63.80	39.86

Table 2: Light use efficiency (LUE) (g/µ mole m-2 s^{-1}) as affected periodically by different treatment

Treatment		Light use efficiency (g/µ mole m^{-2} s^{-1})					
		Days after sowing					
Sowing window	Cultivar	24	42	56	72	84	Harvest
S_1: 26 MW (26th June – 01st July)	V_1 : ICTP-8203	0.50	0.95	1.07	2.42	1.71	1.46
	V_2 : Dhanashakti	0.57	1.06	1.46	2.86	2.20	1.70
	V_3 : Parbhani sampada	0.51	1.02	1.19	2.58	1.91	1.55
S_2: 30th MW (23rd July – 29th July)	V_1 : ICTP-8203	0.60	1.12	1.58	3.04	1.97	1.83
	V_2 : Dhanashakti	0.62	1.26	2.28	3.56	2.26	2.30
	V_3 : Parbhani sampada	0.60	1.21	2.00	3.24	2.03	1.94

S_3 – 33 MW (13th Aug – 19th Aug)	V_1 : ICTP-8203	0.51	0.80	1.18	2.75	1.82	1.29
	V_2 : Dhanashakti	0.53	0.92	1.76	3.23	2.01	1.59
	V_3 : Parbhani sampada	0.52	0.85	1.46	2.95	1.99	1.42

Table 3: Yield attributes of pearl millet as influenced by different treatments

Treatments	Yield (kgha^{-1})			Harvest index (%)
	Grain	Fodder	Biological	
Sowing window				
S_1 26 MW (26th June – 01st July)	1695.22	3169.67	4671.89	35.13
S_2 30 MW (23rd July – 29th July)	1990.33	3688.56	5485.89	3649.
S_3 – 33 MW (13th Aug – 19th Aug)	1835.22	3506.33	5148.56	35.99
S.Em±	34.58	18.49	34.18	0.46
C.D. at 5%	135.78	72.59	134.19	0.18
Cultivars				
V_1 ICTP-8203	1666.67	3228.56	4702.22	34.73
V_2 Dhanashakti	1978.56	3707.44	5493.00	37.10
V_3 Parbhani sampada	1875.56	3428.56	5111.11	35.79
S.Em±	39.82	36.92	59.64	0.57
C.D. at 5%	122.69	113.77	183.76	0.18
Interaction				
S.Em±	68.97	63.95	103.29	0.32
C.D. at 5%	NS	NS	NS	NS
General mean	1840.26	3454.85	5102.11	35.87

Conclusion

The pearl millet cultivar Dhanashakti absorbed more photosynthetically active radiation (APAR), produced more light use efficiency (LUE) and heat use efficiency as compared to Parbhani Sampada and ICTP- 8203 during the period of experimentation. The cultivar Parbhani Sampada also absorbed more photosynthetically active radiation (PAR), produced more light use efficiency (LUE) and heat use efficiency than ICTP-8203 during the period of experimentation. The crop sown in 33th MW also significantly produced more grain, fodder and biological yields over the crop sown in 26thMW during the period of experimentation. These yields were significantly the lowest when crop was sown early in 26thMW. The harvest index was significantly the lowest when crop was sown in 26th MW. It can be summarized with above results that *kharif* pearl millet be sown in 30th MW (23rdJuly – 29th July) with Dhanashakti cultivar for higher yield and maximum B:C ratio.

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