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Effect of Weather Parameters on Pearl Millet (*Pennisetum glaucum* L.) Cultivars under Different Sowing Windows

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A B S T R A C T

Present invitation entitled "Effect of weather parameters on pearl millet (*Pennisetum glaucum* L.) Cultivars under different sowing windows" was carried out during 2013-17 at Zonal Agricultural Research Station, Solapur, Maharashtra State (India). The experiment was conducted in split plot design with three replications. Nine treatment combinations were formed considering different cultivars viz., V_1 (ICTP-8203), V_2 Mahyco Hybrid and V_3 Dhanashakti and sowing windows viz., (S_1) 2nd fortnight of June (25th June), (S_2)- 2nd fortnight of July (27th-July) S_3- 2nd fortnight of August (24th-August). Among the three pearl millet sowing window crop sown in second fortnight of July (S_2) produced significantly higher grain yield (1711.2 kg ha^{-1}), biomass yield (3562.6 kg ha^{-1}), total monetary returns (Rs. 35145 ha^{-1}), CUM (319 mm), (MUE) (5.2 Kg ha^{-1} mm), GDD (1958-2277^{0}days), total dry matter (901.7 g m^{-2}), LAI (1.13) and RUE (1.98 g MJ^{-1}) than other sowing dates. Among the genotypes Dhanshakti produced significantly higher grain yield (1574.4 kg ha^{-1}), biomass yield (3192.3 kg ha^{-1}) and total monetary returns (Rs. 31311 ha^{-1}) than other cultivars.

Introduction

Pearl millet (*Pennisetum glaucum* L.) formerly known as pearl, bulrush, spiked or cat-tail millet. Besides providing food and fodder, pearl millet is grown in the, hot and dry climate and also can be grown in areas like arid or semi-arid where rainfall is not sufficient as received erratic and variable amount and also have characteristics to drought tolerant warm season (Sharma *et al.*, 2010). Rainfall, temperature and radiation are major meteorological parameters, which influence all aspects and stages of growth of the crop. It has been reported that millet has many nutritious and medical functions (Yang *et al.*, 2001). Pearl millet grains are also used as a food for poultry and green fodder or dry kadbi for cattle. 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) have reported higher grain yield of summer pearl millet when sown on 15 march and found reduction in grain yield with delay in sowing. Time of sowing varies with the variety, agro climatic

conditions and crop growing season. In fact, proper planting date is important for maximizing cereal grain yields (Witt, 1996) because optimum seeding dates establish healthy and vigorous plants. A significant reduction in grain yield is associated with delayed seeding for a wide range of climatic conditions (Knapp and Knapp, 1978, Dahlke *et al.*, 1993). Lawn *et al.*, (1993) found that differences in development of cereals sown at different times may be explained by considering an optimum temperature. It was reported that the drastic reduction in yield under delayed sowing (Ramshe et al.1986). Keeping in view of the importance the study was aimed to investigate influence of weather parameters on pearl millet (*Pennisetum glaucum* L.) varieties under Solapur condition.

Materials and Methods

The study was conducted at research farm of Zonal Agricultural Research Station, Solapur, Maharashtra State (India) during in year 2013-2017 in the *Kharif* season. The area is positioned at 75^{o} 65' N latitude 75^{o} 90'E longitude and at the altitude of 483.6 meters above the sea level. The experiment was conducted in split plot design with three replications. Nine treatment combinations were formed considering different cultivars viz., V1 (ICTP-8203), V2 Mahyco Hybrid and V_3 Dhanashakti and sowing windows viz., (S1) 2nd fortnight of June (25^{th} June), (S_2)- 2^{nd} fortnight of July (27^{th}-July) S3- 2nd fortnight of August (24^{th}-August). The soil comes under the vertisol (medium black) clayey loam in texture and slightly alkaline (pH-7.4) in nature and having the depth up to 90 cm. The monsoon lasts from June to the end of September, with moderate rainfall. It has an average rainfall of about of 545 mm per year. The annual maximum and minimum temperature ranged between 25.0 to 43.2^{0}C and 7.3 to 27.1^{0} C, respectively. The gross and net plot sizes were 15.0x 6.3 $m^2$and 10.0 x 4.5 m^2, respectively. All the cultivars are were dibbled as per different sowing windows at a spacing of 45 cm x 20cm.

Results and Discussion

Agronomic studies

The crop sown in second fortnight of July (S_2) produced significantly higher grain yield (1711.2 kg ha^{-1}), biomass yield (3562.6 kg ha^{-1}) and total monetary returns (Rs. 35145 ha^{-1}) and it was found at par with crop sown in second fortnight of June (S_1). It might be due to crop sown at second fortnight of July (S_2) gets sufficient period for its biological and reproductive development and ultimately resulted into higher grain yield, biomass yield and total monetary returns. Whereas, adverse situation of all these parameters were experienced by delayed sown crop in 34^{th} and early sowing 26^{th} MW resulted in decreased values of these yield contributing characters. Similar findings were reported by Kaushik and Gautam (1984), (Siddig *et al.*, 2013) and (Maiti and Soto, 1990). It also indicates that crop sown at second fortnight of June (S_1) get sufficient uniform availability of moisture during its life span helps for better yield and monetary benefits. However among the genotypes Dhanshakti produced significantly higher grain yield (1574.4 kg ha^{-1}), biomass yield (3192.3 kg ha^{-1}) and total monetary returns (Rs. 31311 ha^{-1}). This indicates sustainability of Dhanshakti variety over other varieties. This might be due to short duration life span of Dhanshakti than other varieties and at reproductive stage ICTP-8203 and Mahyco hybrid might be faced moisture stress condition. The results were collaborated with finding of Bashir *et al.*, (2014) and Uzoma *et al.*, (2010). Sustainable Yield Index (SYI) was used as an approach to evaluate the minimum yield likely to be achieved in relation to changes in sowing windows. SYI

of July sown crop is higher (0.59) as compared early (June sown-0.39) and late sown crop (August sown-0.49). In response to change in climate treatment S_3 *i.e.* August sown pearl millet found better in respect of SYI further, on the basis of SYI it can be included as a contingent crop for its sustainable yield of 1002.8 Kg ha^{-1} (Table 1–4).

Meteorological studies

The mean consumptive use of moisture (CUM) (319 mm) and mean moisture use efficiency (MUE) (5.2 Kg ha^{-1} mm) was significantly higher recorded by crop sown in second fortnight of July (S_2) over rest of the sowing windows. It indicates that early and delay in sowing of crops results in recording low value of CUM and MUE. This might be due to July sown crop gets sufficient period to utilize available soil moisture along with good weather for grain production. Dhanshakti recorded highest mean value of CUM (315 mm) and MUE (4.9 Kg ha^{-1} mm). This indicates that the Dhanshakti variety utilized the moisture most efficiently for productions of grains. The mean number of days required to attain the physiological maturity stages recorded higher in July sown crop (S_2) (Table 5). This might be due to more favorable conditions prevailed in case early sown crop and vice versa. Dhanshakti required more mean number of days to attain physiological stages (104 days) than ICTP- 8203 (97 days) and Mahyco hybrid (92 days). This indicates Dhanshakti variety required more number of days to attain physiological maturity than other varieties during *kharif* season under dryland conditions.

The growing degree days (GDD), the function of maximum, minimum and base temperature were presented in Table 6. The data revealed that the growing degree days (GDD) required was 1515-1805^0 days, 1958-2277^{0}days and 1047-1345^0 days for S_1, S_2 and S_3 sown crop. Further, it is seen that S_2 sown crop required more growing degree days to attain physiological maturity. However, among the varieties the values were higher in Dhanshakti followed by Mahyco hybrid and ICTP-8203 variety. This is due to more duration required by S_2 sown crop and Dhanshakti variety. Further, it was also noticed that the early sown crop not received fairly good amount of rainfall during its growth period due to which soil moisture available was less, however, late sown crop favours due to moisture availability during flowering and grain filling stage which resulted in more duration required for maturity and good yield. The second fortnight of July (S_2) sown crop required more number of days to attain various growth stages. This is due to existence of favourable condition for crop growth and development. This is because the GDD which is function of temperature which in turn is a function of bright sunshine hours.

The mean maximum values of total dry matter were recorded by S_2 sown crop i.e. 901.7 g m^{-2} over rest of the sowing windows (Table 7). Data revealed that as the delay in sowing of *kharif* pearl millet there is considerable reduction in mean total dry matter. Among the genotype Dhanshakti variety recorded highest values of mean total dry matter (1010.6 g m^{-2}) in almost all the growth stage than the other varieties (Table 7). This indicates that the Dhanshakti utilized more efficiently moisture, light and temperature and produced maximum total dry matter by maximum solar radiation interception.

The highest mean values of LAI and RUE recorded by the crop sown in second fortnight of July (1.13 & 1.98 g MJ^{-1}) (Table 8 & 9) at 50 per cent flowering stage in almost all the sowing dates and genotypes. It was also revealed that with delayed sowing recorded low mean values of LAI and RUE. This

indicated that the rate of conversion of light *i.e.* photosynthetically active radiation (PAR) was considerably high at 50 per cent flowering stage, thereafter the conversion rate was declined due to ageing of leaves. Among the sowing windows maximum mean RUE values were higher in July sown crop than late sown crop. Further, it was seen that Dhanshakti showed higher values of RUE than Mahyco and ICTP-8203 variety for conversion of light into dry matter in all the dates of sowing (Table 8 & 9).

The data in respect of mean total dry matter showed that the maximum values were recorded by Dhanshakti variety in all the windows of sowing. The July (S2) sown crop has taken maximum number of days than late sown crops to attain the different growth stages during the crop growth period. This is due to better amount of moisture available and low values of temperature during the crop growth period of July sown crops. The same trend was obtained in case of GDD this indicates that GDD is a function of bright sunshine hours which reflected into a better grain yield.

Correlation and regression studies

The weather parameter influence their contribution and performance in *kharif* pearl millet crop sown in different sowing windows were assessed in tenure of phasewise correlation and regression (Table 10-12).

Table.1 Pooled grain yield (kg ha^{-1}) of *kharif* pearl millet as influenced by various sowing dates and varieties (2013 to 17)

Treatment	2013	2014	2015	2016	2017	Mean	Sur/def (%)	SYI
Main=3 Sowing dates								
S_1 = MW 26 (June 26-July01) 2nd fortnight of June	2271.0	1452.4	935.4	1719.8	888.1	1453.3	4.6 % high over mean	**0.39**
S_2 = MW 30 (July 23-29) 2nd fortnight of July	1753.2	2005.5	1512.6	2185.3	1099.8	1711.3	23.2 % high over mean	**0.59**
S_3 = MW 35 (August 27-2 Sept) 2nd fortnight of August	1146.0	560.4	1268.0	1328.7	710.7	1002.8	27.8 % less over mean	**0.49**
Mean	**1723.4**	**1339.5**	**1238.7**	**1744.6**	**899.5**	**1389.1**		**0.59**
Sub=Three varieties								
V_1= ICTP-8203	1468.2	1253.8	1109.6	1598.5	769.1	1239.8	10.7 % less over mean	**0.57**
V_2 = Mahyco hybrid	1689.0	1288.6	1252.8	1682.7	852.6	1353.2	2.6 % high over mean	**0.59**
V3= Dhanshakti	2013.0	1476.0	1353.6	1952.6	1076.9	1574.4	13.3 % high over mean	**0.58**
Mean	**1723.4**	**1339.5**	**1238.7**	**1744.6**	**899.5**	**1389.1**		**0.59**
S.E.± (Sowing dates)	99.98	44.90	39.2	74.5	70.3	159.9		
C.D. at 5 %	392.58	176.28	153.9	292.5	275.9	521.6		
S.E.± (Varieties)	70.92	57.30	57.1	52.0	48.1	35.7		
C.D. at 5 %	218.54	176.57	175.8	160.3	148.1	104.2		
S.E.± (SD X V)	122.84	99.25	98.8	90.1	83.2	61.8		
C.D. at 5 %	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**		

Table.2 Mean Fodder yield (kg ha^{-1}) of *kharif* pearl millet as influenced by various sowing dates and varieties (2013 to 17)

Treatment	2013	2014	2015	2016	2017	Mean	SYI
Main=3 Sowing dates							
S_1 = MW 26 (June 26-July01) 2nd fortnight of June	3126.9	3157.2	2047.4	3046.7	1828.0	2641.3	**0.63**
S_2 = MW 30 (July. 23-29) 2nd fortnight of July	4937.7	4671.2	2775.2	3393.2	2035.9	3562.6	**0.47**
S_3 = MW 35 (August 27-2 Sept) 2nd fortnight of August	2767.9	1493.5	2634.7	2665.4	1599.3	2232.2	**0.58**
Mean	**3610.9**	**3107.3**	**2485.8**	**3035.1**	**1821.1**	**2812.0**	**0.59**
Sub=3 varieties							
V1= ICTP-8203	3313.9	3029.7	2174.3	2723.7	1634.2	2575.2	**0.57**
V_2 = Mahyco hybrid	3457.2	2674.9	2435.5	2984.8	1790.9	2668.7	**0.59**
V3 = Dhanshakti	4061.5	3617.2	2847.5	3396.9	2038.1	3192.3	**0.59**
Mean	**3610.9**	**3107.3**	**2485.8**	**3035.1**	**1821.1**	**2812.0**	**0.59**
S.E.± (Sowing dates)	115.62	99.51	109.7	109.7	65.8	307.1	
C.D. at 5 %	453.98	390.72	430.6	430.6	258.4	1001.5	
S.E.± (Varieties)	145.81	156.22	120.7	120.7	72.4	81.1	
C.D. at 5 %	449.28	481.35	371.8	371.8	223.1	236.7	
S.E.± (SD X V)	252.55	270.57	209.0	209.0	125.4	140.5	
C.D. at 5 %	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	

Table.3 Mean total monetary returns (Rs ha^{-1}) of *kharif* pearl millet as influenced by various sowing dates and varieties (2013 to 17)

Treatment	2013	2014	2015	2016	2017	Mean	SYI
Main=3 Sowing dates							
S_1 = MW 26 (June 26-July01) 2nd fortnight of June	29236	28100	23074	31891	22332	26927	**0.72**
S_2 = MW 30 (July. 23-29) 2nd fortnight of July	39201	39426	30445	39566	27086	35145	**0.74**
S_3 = MW 35 (August 27-2 Sept) 2nd fortnight of August	21291	11393	26400	25261	18212	20511	**0.55**
Mean	**29909**	**26306**	**26640**	**32239**	**22543**	**27528**	**0.74**
Sub=3 varieties							
V_1= ICTP-8203	25099	24241	24092	29425	19467	24465	**0.71**
V_2 = Mahyco hybrid	29259	25304	26733	31210	21529	26807	**0.74**
V_3 = Dhanshakti	35369	29374	29094	36082	26634	31311	**0.75**
Mean	**29909**	**26306**	**26640**	**32239**	**22543**	**27528**	**0.74**
S.E.± (Sowing dates)	1437.17	815.3	670.5	1290.0	1522.6	2179.1	
C.D. at 5 %	5643.03	3201.2	2632.6	5065.2	5978.4	7106.6	
S.E.± (Varieties)	867.80	1138.0	737.5	725.3	993.0	592.7	
C.D. at 5 %	2673.96	3506.5	2272.4	2234.9	3059.7	1729.9	
S.E.± (SD X V)	1503.07	1971.1	1277.3	1256.3	1719.9	1026.6	
C.D. at 5 %	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	

Table.4 Mean CUM and MUE as influenced by sowing windows and varieties in *Kharif* pearl millet (2013 to 17)

Treatment	GY (kg ha^{-1})	CUM (mm)	MUE (kg ha^{-1} mm)
S_1V_1	1358.9	290	4.7
S_1V_2	1448.5	304	4.8
S_1V_3	1552.7	314	4.9
S_2V_1	1542.9	317	4.9
S_2V_2	1631.9	308	5.3
S_2V_3	1959.1	332	5.9
S_3V_1	817.7	270	3.0
S_3V_2	979.2	285	3.4
S_3V_3	1211.4	300	4.0

Table.5 Mean number of days required to attain phenological stages as influenced by sowing windows and varieties in *kharif* pearl millet (2013 to 17)

Sowing Time	Phenological stage							
	Emer.	3 leaf	PI	Flag leaf	50 % flowering	Soft dough	Hard dough	Phy. Maturity
S_1V_1	8	7	18	22	11	13	14	9
Cumulative	8	15	33	55	66	79	93	102
S_1V_2	8	8	15	19	12	14	11	10
Cumulative	8	16	31	50	62	76	87	97
S_1V_3	8	8	18	22	11	17	14	9
Cumulative	8	16	34	56	67	84	98	107
S_2V_1	8	7	15	23	15	13	12	10
Cumulative	8	15	30	53	68	81	93	103
S_2V_2	6	4	14	22	14	14	13	09
Cumulative	6	10	24	46	60	74	87	96
S_2V_3	8	8	16	27	15	16	14	09
Cumulative	8	14	30	57	72	88	102	111
S_3V_1	6	5	14	22	10	10	11	9
Cumulative	6	11	25	47	57	67	78	87
S_3V_2	5	5	15	19	11	8	11	9
Cumulative	5	10	25	44	55	63	74	83
S_3V_3	6	6	16	23	12	11	12	7
Cumulative	6	12	28	51	63	74	86	93

Table.6 Mean growing degree days (^{0}C) required to attain growth stages as influenced by sowing windows and varieties in *kharif* pearl millet (2013-17)

Sowing Time	Phenological stage							
	Emer.	3 leaf	PI	Flag leaf	50 % flowering	Soft dough	Hard dough	Phy. Maturity
S_1V_1	52	41	309	325	235	201	194	180
Cumulative	52	90	395	717	949	1147	1338	1515
S_1V_2	60	56	368	283	260	219	233	221
Cumulative	60	113	478	758	1015	1231	1461	1679
S_1V_3	58	45	416	378	276	210	212	232
Cumulative	58	100	513	888	1161	1367	1576	1805
S_2V_1	69	50	453	383	291	255	232	248
Cumulative	69	116	565	945	1232	1484	1713	1958
S_2V_2	53	49	417	362	279	205	216	185
Cumulative	53	98	512	870	1146	1348	1561	1742
S_2V_3	75	64	539	449	314	284	267	308
Cumulative	75	135	671	1117	1428	1709	1972	2277
S_3V_1	36	31	254	248	106	113	112	161
Cumulative	36	65	316	563	666	778	888	1047
S_3V_2	49	36	279	259	144	125	112	163
Cumulative	49	82	359	616	757	880	990	1151
S_3V_3	52	38	308	298	153	183	143	186
Cumulative	52	87	393	689	840	1021	1161	1345

Table.7 Mean periodical dry matter (g m^{-2}) and its partitioning into different parts of *kharif* pearl millet as influenced by sowing windows and varieties (2013 to 17)

Sowing	Growth Stage					
Date	Emer.	PI	50% flow.	Soft Dough	Hard Dough	Phy. Maturity
			Total			
S1V1	0.7	146.7	353.4	708.5	920.5	762.9
S1V2	0.7	112.9	319.6	712.4	924.4	769.4
S1V3	0.9	83.2	289.9	746.4	958.4	793.0
S2V1	0.9	168.8	375.5	790.7	1032.7	872.7
S2V2	0.9	147.8	354.5	800.0	962.3	902.4
S2V3	0.8	181.2	387.9	829.9	989.7	930.1
S3V1	0.9	149.1	355.8	749.6	988.6	829.9
S3V2	0.9	207.9	414.6	772.5	1014.5	854.5
S3V3	1.0	89.2	295.9	788.4	1050.4	890.4

Table.8 Mean leaf area index as influenced by sowing windows and varieties in *Kharif* pearl millet (2013 to 17)

Sowing Time	Phenological stage						
	Emer.	PI	Flag leaf	50 % flowering	Soft dough	Hard Dough	Phy. maturity
S1V1	0.03	0.39	0.72	1.00	1.09	0.77	0.39
S1V2	0.03	0.27	0.56	0.84	0.93	0.47	0.34
S1V3	0.03	0.31	0.65	0.93	1.02	0.55	0.25
S2V1	0.06	0.56	1.14	1.42	1.51	1.22	0.91
S2V2	0.04	0.38	0.92	1.20	1.29	0.61	0.52
S2V3	0.05	0.49	1.06	1.34	1.43	1.10	0.77
S3V1	0.04	0.34	0.78	1.06	1.15	0.67	0.57
S3V2	0.05	0.31	0.72	1.00	1.09	0.90	0.47
S3V3	0.04	0.41	0.72	1.00	1.09	0.92	0.47

Table.9 Mean radiation use efficiency (g MJ^{-1}) as influenced by sowing windows and varieties in *kharif* pearl millet (2013 to 17)

Sowing Time	Phenological stage						
	Emer.	PI	Flag leaf	50 % flowering	Soft dough	Hard Dough	Phy. maturity
S_1V_1	0.08	0.21	0.84	0.95	0.93	0.83	0.72
S_1V_2	0.06	0.08	0.62	1.89	0.62	0.50	0.37
S_1V_3	0.06	0.14	0.74	1.68	0.89	0.73	0.56
S_2V_1	0.13	0.25	1.40	1.84	1.55	1.24	1.14
S_2V_2	0.10	0.20	0.82	1.85	1.31	1.16	0.95
S_2V_3	0.10	0.22	1.45	2.24	1.62	1.38	1.12
S_3V_1	0.13	0.26	1.26	1.11	1.41	1.19	1.10
S_3V_2	0.13	0.44	1.15	1.31	1.04	1.08	0.67
S_3V_3	0.32	0.32	0.87	1.44	1.24	1.13	0.79

Table.10 Correlation coefficient between grain yield and different weather parameters during different phenophases of *kharif* pearl millet

Phenophase	MAXT (^{0}C)	MINT (^{0}C)	RH1 (%)	RH2 (%)	WS (kmph)	RF (mm/day)	SS (hrs/day)	EVP (mm/day)
P1	-0.270	0.220	-0.308	0.355	0.805**	-0.147	-0.471	0.411
P2	-0.148	0.246	-0.461	-0.250	0.607	-0.095	-0.314	0.435
P3	0.746*	0.419	-0.859**	-0.671*	0.451	-0.768*	-0.025	0.525
P4	-0.608	0.584	0.641	0.758*	0.400	0.334	-0.613	0.668*
P5	-0.438	0.678*	0.771*	0.683*	0.170	0.823**	-0.475	0.748*
P6	0.353	0.398	0.328	0.159	0.080	0.250	0.066	0.836**
P7	0.326	0.303	0.105	0.239	0.012	0.028	-0.125	0.213
P8	0.153	0.176	-0.043	0.082	0.264	0.159	0.022	0.396

Table.11 Stepwise multiple regression of different weather parameters with yield of *kharif* pearl millet at 50% flowering stage (2013 to 2017)

Sr. No.	Weather parameter	Regression coefficient	R^2
1	Intercept	-101.38	**0.81**
2	Minimum Temperature (T_{min})	-0.21	
3	Relative Humidity (RH-1)	2.49	
4	Relative Humidity (RH-2)	-1.34	
5	**Rainfall (RF)**	**0.08**	

Table.12 Observed and predicted yield by using linear regression equations

Treatment	Actual Yield	Predicted Yield	Residuals	Standardized residual
Main treatment – Sowing time				
S_1 = MW 26 (June 26-July01) 2nd fortnight of June	1533.4	1501.5	-31.9	-0.63
S_2 = MW 30 (July. 23-29) 2nd fortnight of July	1757.0	1829.2	72.2	1.15
S_3 = MW 35 (August 27-Sept 2) 2nd fortnight of August	1034.2	1008.0	-26.2	-0.53
Sub treatment – variety				
V_1= ICTP-8203	1418.6	1298.6	-120.0	-1.15
V_2 = Mahyco hybrid	1365.9	1425.3	59.4	0.51
V_3 = Dhanshakti	1540.1	1614.8	74.7	0.65

$\sqrt{Yield} = -101.38 + (-0.21 \times T_{min}) + (2.49 \times RH\text{-}1) + (-1.34 \times RH\text{-}2) + (0.08 \times RF)$

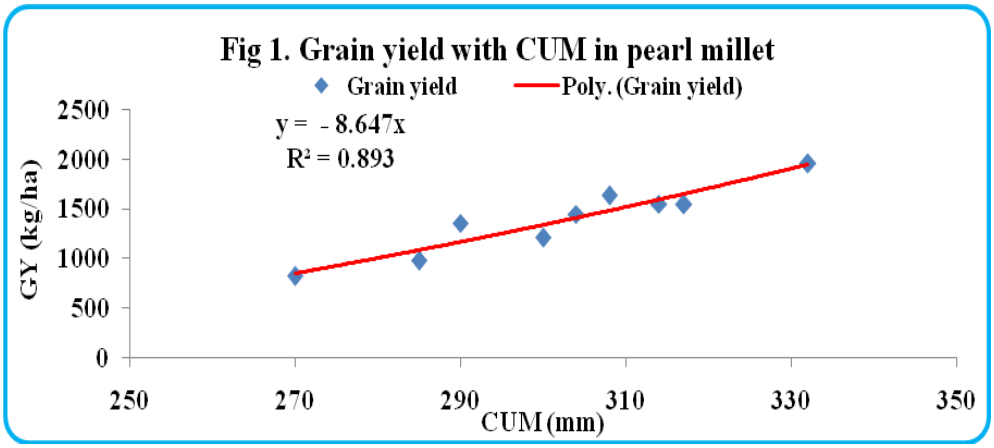
Standard Residual > 3 is outleter,

T_{min} = Min. Temperature (^0C)

RH-1 = Morning relative humidity (%)

RH-2 = Evening relative humidity (%)

RF = Rainfall (mm)



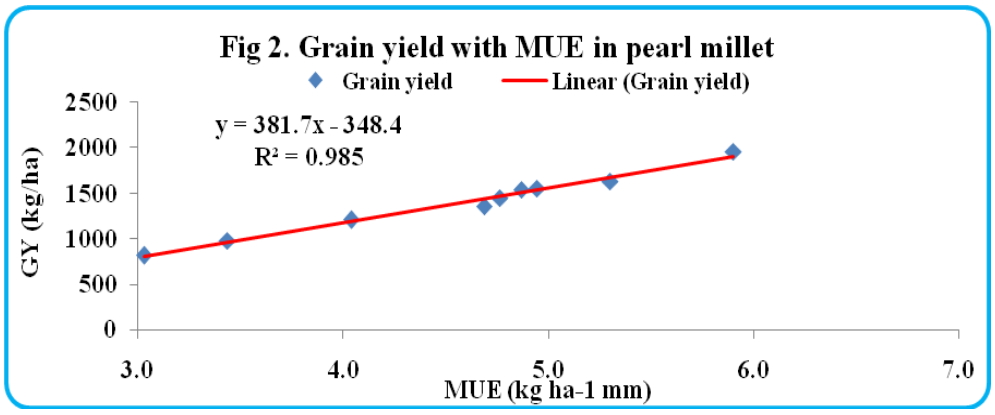


Fig 2. Grain yield with MUE in pearl millet
Grain yield
Linear (Grain yield)
y = 381.7x - 348.4
R² = 0.985
GY (kg/ha)
2500
2000
1500
1000
500
0
3.0
4.0
5.0
6.0
7.0
MUE (kg ha-1 mm)

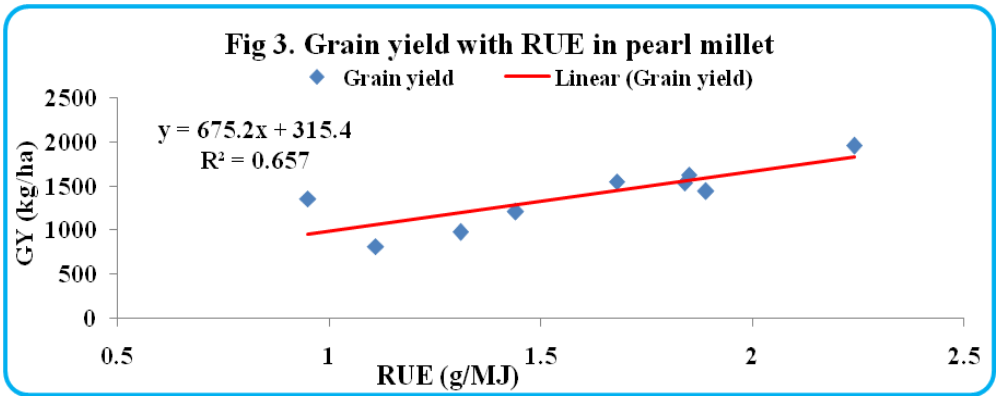


Fig 3. Grain yield with RUE in pearl millet
Grain yield
Linear (Grain yield)
y = 675.2x + 315.4
R² = 0.657
GY (kg/ha)
2500
2000
1500
1000
500
0
0.5
1
1.5
2
2.5
RUE (g/MJ)

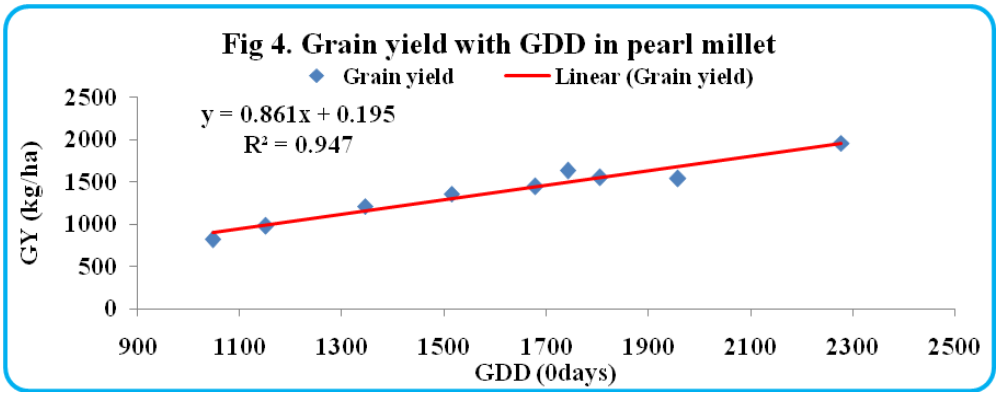


Fig 4. Grain yield with GDD in pearl millet
Grain yield
Linear (Grain yield)
y = 0.861x + 0.195
R² = 0.947
GY (kg/ha)
2500
2000
1500
1000
500
0
900
1100
1300
1500
1700
1900
2100
2300
2500
GDD (0days)

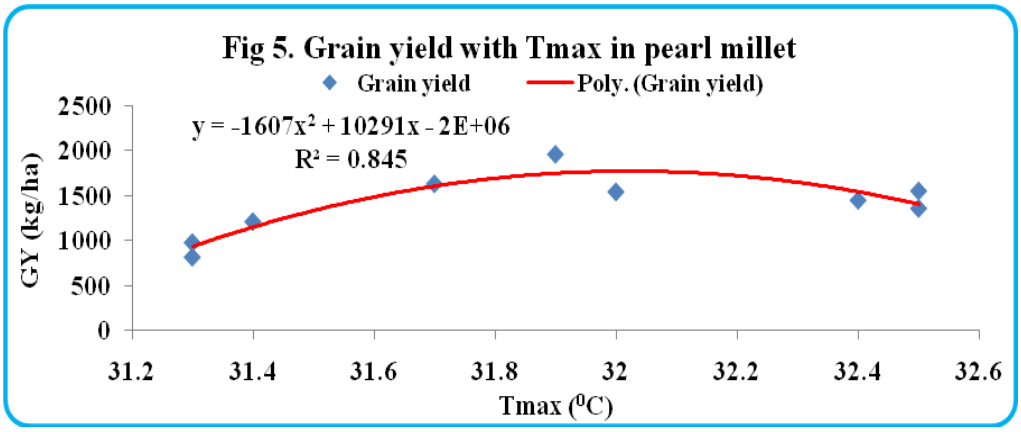
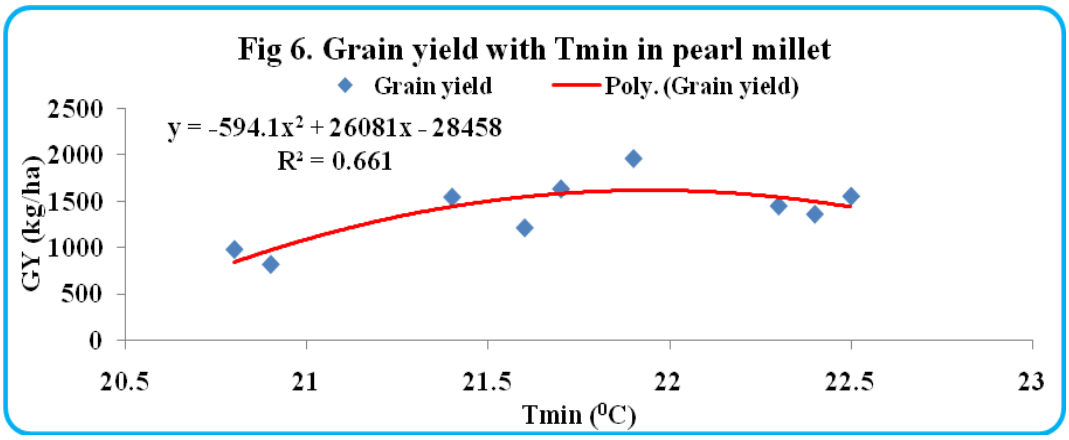


Fig 5. Grain yield with Tmax in pearl millet
Grain yield
Poly. (Grain yield)
y = -1607x² + 10291x - 2E+06
R² = 0.845
GY (kg/ha)
2500
2000
1500
1000
500
0
31.2
31.4
31.6
31.8
32
32.2
32.4
32.6
Tmax (⁰C)



The influence of weather parameter and agrometeorological indices on performance of *kharif* pearl millet crop sown at different windows with different varieties were assured in terms of phase-wise correlation of grain yield with weather parameters. It is revealed that the wind speed had significant positive correlation at emergence phase (P1). Tmax had significant positive influence and RH-1, RH-2 and RF has significant negative influence at panicle initiation phase (P3). RH-2 and Epan had significant positive correlation at flag leaf stage (P4). Significant positive correlation was found with T_{min}, RH-1, RH-2, RF and E_{pan} at 50 % flowering stage (P5) while at soft dough stage Epan had significant positive association with grain yield. Significant negative association with grain yield by T_{min}, RH-1, RH-2 and RF at panicle initiation phase (P3) indicates that at early growth stages *kharif* pearl millet not favour moisture stress condition. Significant positive association with grain yield at 50 % flowering stage by T_{min}, RH-1, RH-2, RF and E_{pan} indicates *kharif* pearl millet responds well to available moisture and low temperature conditions. It is revealed that panicle initiation stage (P3) and 50% flowering stage (P5) are more crucial growth stages to contribute grain production.

It is observed that the significantly positive correlation (Table 10) of weather parameters namely Tmin, RH-1, RH-2 and RF with grain yield at 50% flowering phase. The predicted grain yield and actual pooled grain yield is presented in Table 12. The regression equation is developed by using this weather parameters *i.e.* √Yield= -101.38 + (-0.21×Tmin) + (2.49×RH-1) + (-1.34×RH-2) + (0.08×RF). This equation is helpful to predict grain yield after completion of 50% flowering phase (P5) (Table 11 and 12).

The consumptive use of moisture (CUM) during total growth period of *kharif* pearl millet Fig. 1 showed a polynomial relationship with grain yield ($y=0.0437x^2$-8.6471xR^2 = 0.89). The CUM of 310 mm was found to be optimum for getting higher grain yield. The moisture use efficiency (MUE) during total growth period of *kharif* pearl millet Fig. 2 showed a linear relationship with grain yield (y = 381.76x – 348.47 R^2 = 0.98). The MUE of 4.5 to 5.5 kg ha mm^{-1} was found to be optimum for getting higher grain yield. The RUE studies depicted in Fig. 3 showed linear relationship with grain yield.

This indicated that radiation interception is directly related with grain yield (y=675.25x+315.49 R^2 = 0.66). The figure showed that if RUE increases from 1.5 to 1.9 g mj^{-1} it increases the yield from 07 to 14 q ha^{-1}. This indicated that every increase of 0.1 gmj^{-1} of energy there is increase of 0.94 q ha^{-1} of grain yield of pearl millet.

The GDD was correlated with the grain yield of pearl millet and depicted in Fig. 4. It showed a linear relationship with grain yield ($y=0.861x+0.1952$ $R^2 = 0.95$). This indicated that with increase of GDD there was increase in grain yield upto 1800 GDD. The T_{max} was correlated with the grain yield of pearl millet and depicted in Fig. 5. It showed a polynomial relationship with grain yield ($y=-1607x^2+102918x-2E+06$ $R^2 = 0.85$). This indicated that with increase of T_{max} there was increase in grain yield upto 31.9^0C and later on yield decrease with increase in T_{max}. The T_{min} was correlated with the grain yield of pearl millet and depicted in Fig. 6. It showed a polynomial relationship with grain yield ($y=-594.18x^2+26081x-284580$ $R^2 = 0.66$). This indicated that with increase of T min there was increase in grain yield upto 21.9^0C later on yield decrease with increase in T_{min}

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