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Ensuing economic gains from summer pearlmillet (*Pennisetum glaucum* L.) due to different dates of sowing and land configuration

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This study was undertaken at Navsari, India (20.95°N 72.93°E, elevation of 10 m above Sea level) during summer season 2010 to work out effect of different land configuration and dates of sowing on pearlmillet. The results gained confirm that ridges and furrow along with early sowing date during summer season is beneficial to obtain higher net returns from pearlmillet crop. Ridges and furrow sowing of pearlmillet showed superiority in all needed agronomic trait of pearlmillet crop during summer and the increase in grain and stover yield under ridges and furrow was 20.00 and 17.71% over flat bed sowing, respectively. The economic returns by application of ridge and furrow bed sowing gave net returns of Rs.14081 ha^{-1} and B:C ratio of 1.88 while, in flat bed treatment those were Rs.10181.04 ha^{-1} and 1.67, respectively. Sowing pearlmillet during last week of January or first week of February increases the yield as well as net returns from the crop. Pearlmillet sown on 5 February (3.24 t ha^{-1}) gave significantly highest grain yield followed by 25 January (3.04 t ha^{-1}) sowing, while 15 February sowing gave significantly lowest yield. Highest net returns of Rs.15541 ha^{-1} with B:C ratio of 2.03 were obtained with 5 February sowing treatment, followed by 25 January sowing treatment with Rs.13971 ha^{-1} and 1.93 B:C ratio respectively. Whereas, the lowest net returns and B:C ratio was acquire from 15 February, that is, Rs. 8341 ha^{-1} and 1.55, respectively.

Key words: Summer pearlmillet, land configuration, ridges and furrow, dates of sowing.

INTRODUCTION

India is one of the major producers of millets in world. The predominant millets grown in India are sorghum (*jowar*), pearl millet (*bajra*), finger millet (*ragi*), kodo millet (*kodo*), proso millet (*cheena*), little millet (*kutki*), foxtail millet (*kangni*) and barnyard millet (*sawa*); of which barnyard millet, little millet and kodo millet are endemically domesticated in Indian subcontinent. Millets are warm weather grasses belonging to C_4 group of plants and considered as physiologically efficient. Their cultivation in India extends from sea-level up to 2,000 m above mean sea-level and often grown in diverse soils, climates and harsh environments. Millets have been important food and feed crops producing more reliable harvests than many other crops.

Pearlmillet is commonly known in India as *Bajri* or *Bajra.* Pearlmillet (*Pennisetum glaucum* L.) is also known as ‘bullrush millet’, originated in tropical western Africa, where the greatest number of both wild ancestors and cultivated forms occur. It belongs to family Gramineae (Poaceae). The cultivated species are *P. glaucum* L. (2n=14) used for grain and fodder and *Pennisetum purpureum* L. (2n=28) used for green and dry fodder. It is highly cross pollinated crop due to protogynous nature of the flowers (more than 85% outcrossing) diploid annual (2n=2x=14) with a large genome size (2450 Mbp). Average composition of the edible portion of seed is

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12% moisture, 10-12% protein, 3-5% fat, 60-70% carbohydrates, 1.5-3% fibre and 1.5- 2% ash. Its nutritional value is somewhat superior to maize, rice, sorghum and wheat. Stalks are also used for thatching, as fuel and made into mats for winnowing.

Waterlogging in heavy black soil and salt injury due to saline irrigation water are the important factors for low productivity of pearlmillet in south Gujarat mainly during summer season. Under these conditions land configuration can play a vital role to overcome these problems by providing easy and uniform germination as well as good growth and development of plants. Land configuration increases water use efficiency as reported by Chiroma et al. (2008) and also increases availability of nutrients to crops. It is particularly useful in areas having saline irrigation water because it helps to avoid direct contact of young plants with saline irrigation water. The superiority of ridges and furrow system could be ascribed to proper drainage of excess water coupled with adequate aeration at the time of irrigation or heavy rainfall. Parihar et al. (2009) reported that ridges and furrow sowing method improved grain as well as stover yield of pearlmillet and succeeding mustard over the flat bed method of sowing.

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 pearlmillet when sown on 15 march and found reduction in grain yield with delay in sowing. Identifying suitable time of sowing for pearlmillet 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.

But until now very fewer literatures is available on cultivation of summer pearlmillet and keeping this in view, the present investigation was undertaken.

MATERIALS AND METHODS

The field experiment was conducted at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari during summer season of 2010. Geographically, Navsari is located at 20.95°N latitude, 72.93°E longitude and at height of 9 m above the mean sea level.

Normally, the summer season commences from the middle of February and ends by the middle of June. The temperature starts rising from February and reaches the maximum in the months of April and May, which are the hottest months of season. The weekly mean maximum and minimum temperature varied from 29.8 to 38°C and 13.2 to 28.8°C, respectively during the course of investigation. The maximum and minimum relative humidity ranged from 68 to 91% and 26 to 73%, respectively and daily sunshine hours from 7.5 to 10.8 were available during the crop period. There was no rainfall during the crop season. Thus, the weather conditions were normal and congenial for satisfactory growth of pearlmillet crop.

The soils of South Gujarat are locally known as 'Black Cotton Soil'. The soil of Navsari campus falls under the great group *Ustochrepts* and has been placed under Jalalpur series. These soils are dominated by montmorillonite clay, which cracks heavily after drying. The soil of the experimental site was dark grayish brown type having medium to poor drainage and good water holding capacity.

Data on soil analysis as analyze using standard methods from Jackson (1967) revealed that soil of experimental field was clay in texture, medium in available nitrogen and phosphorus and high in available potassium. The soil was slightly alkaline in reaction with normal electrical conductivity.

Pearlmillet crop was sown with 4 kg ha^{-1} seed rate at 45 × 10 cm spacing with drill method in North-South direction as per treatments in the experimental field. The fertilizer dose used throughout experiment was 120-60-00 NPK kg ha^{-1}. The first irrigation was given just after sowing for germination and subsequently irrigations were applied accordingly during crop period as required. Two hand weeding were done to check the weed population. No serious disease and pest were observed during the crop growth period hence no use of insecticide was needed. The data collection for growth and yield attributes was done from randomly selected five plants and then by calculating the average value for each plot. After maturity of crop, harvesting was followed by removing the earheads from plant and subsequently the plants were harvested by sickle from each plot. The yield observations were calculated from whole net plot plant population and then converted to hectare basis.

The treatment combinations comprise of two levels of land configurations *viz*., flat bed (L_1) and ridges and furrow (L_2) and three dates of sowing, that is, 25 January (D_1), 5 February (D_2) and 15 February (D_3). The data recorded on various characters during the period of investigations were statistically analysed by appropriate procedure to the factorial randomize block design. The significance of differences was tested by the 'F' test at 5% level (Panse and Sukhatme, 1967). The critical differences were calculated when the differences among treatments were found significant by 'F' test. Summary tables of treatment means have been prepared and presented with standard error of mean (S.Em ±) and coefficient of variation (C.V. %).

RESULTS AND DISCUSSION

Effect of weather on pearlmillet crop in summer season

The results on growth and yield attributes, yield, nutrient content and uptake as well as water use efficiency data were presented in the previous chapter indicated profound effect of environment factors. Weather condition plays an important role on the growth and yield of pearlmillet in summer season. It is evident from the meteorological data that the weather condition prevailed during the entire crop period was favorable and congenial for the normal growth and development of pearlmillet crop. No severe incidences of diseases and pests were observed during the entire crop growth period. Thus, it is expected that the variation observed in the experimental results were mainly due to the treatment effects only.

Effect of soil

The soil properties *viz.,* texture, pH, EC and available nutrients were estimated before sowing. The soil of experimental field was found clayey in texture, slightly

Table 1. Plant height (cm) leaf are index, dry matter (g) and number of tillers of summer pearlmillet at 20, 40, 60 DAS and at harvest as influenced by land configurations and dates of sowing.

Treatment	Plant height (cm)				Leaf area index				Dry matter (g)				Number of effective tillers
	20 DAS	40 DAS	60 DAS	At harvest	20 DAS	40 DAS	60 DAS	At harvest	20 DAS	40 DAS	60 DAS	At harvest	60 DAS
Land configurations (L)													
L_1 = Flat bed	23.51	51.83	156.73	162.70	1.37	3.47	4.99	1.11	6.10	25.27	40.18	45.24	2.83
L_2 = Ridges and furrow	23.84	53.86	166.66	176.28	1.38	3.61	5.36	1.16	6.27	26.59	42.35	47.62	3.19
S.Em.$\pm$	0.30	0.56	1.60	1.97	0.017	0.04	0.08	0.01	0.07	0.35	0.51	0.54	0.05
C.D. at 5%	NS	1.61	4.60	5.66	NS	0.13	0.23	0.04	NS	1.01	1.46	1.55	0.14
Dates of sowing (D)													
D_1 = 25 Jan.	24.11	54.66	167.32	175.09	1.40	3.62	5.52	1.20	6.27	26.67	42.11	47.36	3.09
D_2 = 5 Feb.	23.73	53.20	162.65	168.49	1.38	3.57	5.08	1.12	6.20	26.05	41.74	46.99	3.06
D_3 = 15 Feb.	23.19	50.66	155.11	164.89	1.33	3.43	4.91	1.08	6.08	25.06	39.96	44.94	2.89
S.Em.$\pm$	0.35	0.69	1.96	2.41	0.021	0.05	0.10	0.02	0.09	0.43	0.63	0.66	0.06
C.D. at 5%	NS	1.97	5.63	6.93	NS	0.15	0.28	0.05	NS	1.24	1.79	1.90	0.17

alkaline (pH 7.8), low in available nitrogen (176 kg/ha), with medium availability of phosphorus (32 kg/ha) and fairly rich in potash (350 kg/ha) as analyze using standard methods from Jackson (1967), which is suitable for proper growth and development of pearlmillet crop.

Effect of land configuration on growth and growth attributes

Different techniques of land configuration showed remarkable influence on crop growth. Significant differences in plant height, leaf area index, dry matter accumulation and number of effective tillers per plant (Table 1) at different growth stages of crop was observed due to the effect of various methods of land configuration.

The periodical plant height and leaf area index recorded at various growth stages were significantly higher except 20 DAS under ridges and furrow (L_2). This might be due to maintenance of proper air moisture regimes under ridges and furrow sowing which might have improved the drainage resulting in good supply of required moisture, available nutrients, soil aeration, soil environment and better growth and development. The results were in conformity with those reported by Ugale et al. (1995) for plant height in *kharif* pearlmillet and by Patel et al. (2008) in sorghum.

Better plant height and leaf area index under ridges and furrow (L_2) reflected into significant increase in dry matter accumulation except in 20 DAS) and number of effective tillers per plant. Kiran et al. (2008) observed similar results in sorghum in terms of dry matter accumulation.

Different land configuration treatments did not produce any significant effect on days to 50% flowering and physiological maturity (Table 2).

Effect of dates of sowing on growth and growth attributes

Growth components of pearlmillet *viz.,* plant height, leaf area index, dry matter accumulation, effective number of tillers, days to 50% flowering and days to maturity varied significantly due to time of sowing (Tables 1 and 2). Only the plant height, leaf area index and dry matter accumulation measured at 20 DAS was not significant due to changes in sowing time. Summer pearlmillet sown at normal time on 25 January registered measurable increase in growth components as compared to late sown crop. Thus, results were in favour for sowing of summer pearlmillet on 25 January (D_1) far to on 5 February (D_2) than late sowing, that is, on 15 February (D_3). This is probably due to early sown crop may enjoy favourable climatic conditions in term of

Table 2. Influence of land configurations and dates of sowing on physiology and yield of summer pearlmillet.

Treatment	50% flowering (days)	Physiological maturity (days)	Girth of earhead (cm)	Length of earhead (cm)	Test weight (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})
Land configurations (L)							
L_1 = Flat bed	49.85	81.89	9.00	19.22	11.27	2.65	6.72
L_2 = Ridges and furrow	50.41	82.52	9.64	20.42	11.80	3.18	7.91
S.Em.$\pm$	0.50	0.80	0.15	0.21	0.15	0.08	0.18
C.D. at 5%	NS	NS	0.42	0.59	0.42	0.23	0.53
Dates of sowing (D)							
D_1 = 25 Jan.	51.17	84.06	9.13	20.06	11.88	3.04	7.78
D_2 = 5 Feb.	50.61	82.06	9.98	20.59	11.72	3.24	7.95
D_3 = 15 Feb.	48.61	80.50	8.85	18.81	11.01	2.46	6.21
S.Em.$\pm$	0.62	0.98	0.18	0.25	0.18	0.10	0.23
C.D. at 5%	1.77	2.83	0.51	0.73	0.52	0.28	0.65

temperature and other climatic parameters during various crop growth stages, which reflected into better growth. Similar results of summer pearlmillet growth were observed by Andhale et al. (2007b), Upadhyay et al. (2001), Patel and Patel (2002) and Patel et al. (2004).

Days required to 50% flowering and physiological maturity was also remarkably influenced under varying sowing time. Late sown crop advanced the flowering and maturity over early sowing in summer pearlmillet and 15 February sowing took minimum days to 50% flowering and maturity. It might be due to the availability of required photoperiod to early sown pearlmillet crop at reproductive stage. Similar findings were also reported by Andhale et al. (2007b) in pearlmillet and by Pawade (2010) in maize.

Effect of land configuration on yield attributes and yield

The yield attributes *viz.*, length and girth of earhead and test weight were significantly influenced by land configuration treatments (Table 2).

Significantly higher length and girth of earhead and test weight was recorded under ridges and furrow (L_2) sowing. This might be due to better growth of plant in terms of dry matter accumulation under ridges and furrow sowing which might have adequately supplied more photosynthates for development of sink. The present findings were in accordance with those of Ugale et al. (1995) in pearlmillet and Patel et al. (2008) in sorghum for length and girth of earhead and with Kumar (2008) in maize with respect to test weight.

The better performance of pearlmillet crop observed in terms plant height, dry matter accumulation, and length and girth of earhead and test weight obtained under ridges and furrow (L_2) sowing treatment which in turn converted into the maximum grain and stover yields. An increase in grain and stover yield under ridges and furrow was 20.00 and 17.71% over flat bed sowing, respectively. This might be due to the cumulative effect exerted from better improvement in drainage, soil environment, aeration, root development, optimum moisture-air equilibrium throughout the crop growth besides supply of available nutrients to the crop resulting in better growth and development ultimately reflected in better grain and stover yields. These findings were corroborated the results of Patel et al. (2008) and Kiran et al. (2008) in *rabi* sorghum. Parihar et al. (2009) also found resembling results in pearlmillet for grain and stover yield with sowing on ridges and furrow treatment over flat bed.

Effect of dates of sowing on yield attributes and yield

Various yield attributes *viz.,* length and girth of earhead and test weight were significantly influenced under varying sowing time (Table 2). Crop sown either on 25 January (D_1) or 5 February (D_2) recorded higher values for almost all the above yield characters than late sown crop, that is, on 15 February (D_3).

Better growth of plant in terms of plant height, leaf area and dry matter accumulation under 25 January (D_1) or 5 February (D_2) sowing reflected into better development of yield attributes under early sown crop. Moreover, congenial climatic conditions during early sowing also play vital role in development of yield attributes. These findings are substantiated with those reported by Patel and Patel (2002) and Patel et al. (2004). Thus, the overall better growth and higher values of most of the yield attributes under 5 February sowing resulted into maximum grain yield of 3.24 t ha^{-1} (Table 2), however, it remained statistically at par with 25 January sowing with grain yield (3.04 t ha^{-1}). Late sowing on 15 February recorded lowest grain yield of 2.46 t ha^{-1}. Crop sown on 5 February increased the grain yield by 6.57 and 31.70%, respectively over 25 January and 15 February sowing.

The reason for higher yield in D_1 or D_2 might also be due to ideal maximum temperatures around 29 to 32°C during vegetative and flowering periods resulting in better translocation to reproductive structures, seed set and seed development. When the crop is sown on 15 February, the flowering period coincides with higher mean maximum temperature of around 37 to 38°C, which adversely affected the seed set and translocation of nutrients resulting in poor grain yields. The yield attributing characters such as length and girth of earhead and 1000 grain weight were also significantly higher with the crop sown on D_1 or D_2 dates. These result land support to those reported by Shinde et al. (2003).

Similarly, better development of various growth parameters *viz.,* plant height, dry matter accumulation and leaf area under early sowing reflected into significant variation in stover yield recorded under different sowing times. Though, 5 February sowing produced highest stover yield (7.95 t ha^{-1}) it remained statistically at par with 25 January (7.78 t ha^{-1}). Whereas lowest stover yield (6.21 t ha^{-1}) was recorded under late sowing on 15 February. The crop sown on 5 February increased the stover yield in pearlmillet by 2.19 and 28.02%, respectively over 25 January and 15 February sowings. Similar findings were also reported by Patel and Patel (2002) at S.K. Nagar (Gujarat), Patel et al. (2004) at S. K. Nagar (Gujarat) and Deshmukh et al. (2009).

Effect of land configuration on nutrient content and uptake

Significantly the highest N, P and K content and uptake by grain and stover were recorded under ridges and furrow (L_2) over flat bed (L_1) sowing, except P content in stover. Higher N content (1.746 and 0.712%) and N uptake (55.650 and 56.172 kg/ha), P content (0.350 and 0.092%) and P uptake (11.165 and 7.280 kg/ha) and K content (0.449 and 0.990%) and K uptake (14.289 and 78.244 kg/ha) by grain and stover of pearlmillet, respectively were recorded with the treatment ridges and furrow (Table 3).

This might be attributed to better root growth due to better aeration and good drainage might have also increase microbial activity with optimum moisture and nutrient availability for its growth. The findings were in accordance with those earlier reported by Patel et al. (2008), Parihar et al. (2009) and Dhimmar and Damame (2010).

The total uptake is a function of total biological yield and the nutrient concentration in the tissues. The data showed profound increase in grain and stover yield of summer pearlmillet that ultimately increased the uptake of N, P and K by pearlmillet.

Effect of dates of sowing on nutrient content and uptake

At harvesting, treatment-wise, grain and stover samples were collected and analyzed for N, P and K content. Using content and yield values, uptake of these nutrients was calculated separately for grain and stover. The content of N, P and K in grain was affected significantly due to changes in sowing time. However, P and K content of stover were non-significant, but N content showed significant results with change in sowing time.

Apart from difference in nutrients content, all nutrients *viz*., N, P and K uptakes were found significant in both grain and stover due to different dates of sowing treatments (Table 3). In all these cases (grain and stover content and uptake), treatment D_2 (5 February sowing) showed superiority over rest of the sowing date treatments *viz*., D_1 and D_3. This increase in content and uptake by grain and stover might be due to increased yield of grain and stover under treatment D_2. Similar results were also observed by Andhale et al. (2007a).

Effect of land configuration on economics

It is obvious from the data (Table 4) reported in that ridges and furrow treatment irrespective of land configuration markedly increased the returns over flat bed treatment giving returns of Rs.14081 ha^{-1} and B:C ratio of 1.88. Whereas, the net returns and B:C ratio obtained from flat bed treatment (L_1) were Rs.10181.04 ha^{-1} and 1.67, respectively. This might be due to higher yields of crop gained from ridges and furrow treatment (L_2). It clearly brings out the fact that adoption of ridges and furrow techniques of land configuration was more paying than flat bed techniques. Results of Kiran et al. (2008) and Parihar et al. (2009) add to the compliance of obtained results.

Effect of dates of sowing on economics

From the economics (Table 4) point of view, maximum

Table 3. NPK content and uptake of grain and stover of pearlmillet crop as influence by land configurations and dates of sowing.

Treatments	Grain		Stover		Grain		Stover		Grain		Stover	
	N content (%)	N uptake (kg/ha)	N content (%)	N uptake (kg/ha)	P content (%)	P uptake (kg/ha)	P content (%)	P uptake (kg/ha)	K content (%)	K uptake (kg/ha)	K content (%)	K uptake (kg/ha)
Land configurations (L)												
L_1 = Flat bed	1.713	45.462	0.700	47.063	0.343	9.089	0.090	6.073	0.839	22.220	0.776	52.131
L_2 = Ridges and furrow	1.746	55.650	0.712	56.172	0.350	11.165	0.092	7.280	0.850	27.036	0.790	62.434
S.Em.$\pm$	0.011	1.436	0.004	1.318	0.002	0.273	0.0008	0.187	0.003	0.669	0.005	1.407
C.D. at 5%	0.032	4.130	0.010	3.791	0.006	0.785	NS	0.537	0.008	1.919	0.014	4.036
Dates of sowing (D)												
D_1 = 25 Jan.	1.739	53.072	0.710	55.391	0.349	10.650	0.091	7.110	0.844	25.721	0.786	61.198
D_2 = 5 Feb.	1.750	56.778	0.713	56.324	0.350	11.368	0.092	7.356	0.851	27.563	0.783	62.224
D_3 = 15 Feb.	1.700	41.819	0.694	43.137	0.340	8.362	0.090	5.564	0.837	20.599	0.780	48.425
S.Em.$\pm$	0.014	1.759	0.004	1.615	0.003	0.334	0.001	0.229	0.003	0.820	0.006	1.723
C.D. at 5%	0.039	5.059	0.013	4.643	0.007	0.961	NS	0.658	NS	1.24	1.79	1.90

Table 4. Economics of summer pearlmillet as influenced by land configurations and dates of sowing.

Treatments	Net returns (Rs.)	B:C ratio
Land configurations *(L)*		
L_1 = Flat bed	10181.04	1.67
L_2 = Ridges and furrow	14081.00	1.88
Dates of sowing (D)		
D_1 = 25 January	13971.00	1.93
D_2 = 5 February	15541.00	2.03
D_3 = 15 February	8341.00	1.55

78.244 kg/ha) by grain and stover of pearlmillet, net returns of Rs.15541 ha^{-1} with B:C ratio of 2.03 was obtained with 5 February sowing treatment (D_2), followed by 25 January sowing treatment (D_1) with Rs.13971 ha^{-1} of net returns and 1.93 B:C ratio. Whereas, the net returns and B:C ratio obtained from 15 February (D_3) were Rs. 8341 ha^{-1} and 1.55, respectively. This might be due to higher yields of pearlmillet crop gained from D_2 and D_1 treatments. The results resembled with Sukhadia and Dhoble (1992).

Conclusion

From the results of the experimentation, it can be concluded that for getting higher profitable production of summer pearlmillet should be sown on 5 February on ridges and furrow. In other words, land configuration and dates of sowing ensue in higher economic returns from pearlmillet crop in summer season.

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