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SOWING DATES AND WEED CONTROL PRACTICES EFFECTS ON PRODUCTIVITY AND PROFITABILITY OF PEARL MILLET IN RAJASTHAN

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SUMMARY

A field experiment was conducted at research farm of Agricultural Research Station, Mandor (Jodhpur) during *kharif* 2018 and 2019. During the study, three date of sowing *viz*. 1st April, 1st July and 1st August and five weed control practices *viz*. weedy check, twice hoeing at 15 and 30 days after sowing (DAS), application of atrazine @ 400 g a.i. /ha at 15 DAS, one hoeing through tractor operated weeder at 20 DAS and application of atrazine (PE) @ 500 g a.i. /ha one hoeing through tractor operated weeder at 30 DAS were taken into consideration to evaluate the effect on productivity and profitability of pearl millet. Results indicated that significantly higher plant height (155.6 cm), stem diameter (1.28 cm), leaf area index at 40 DAS (3.61) & 60 DAS (5.62), dry matter at 30 DAS (59.0 g/m^2) 60 DAS (425.3 g/m^2) and at harvest (641.5 g/m^2), effective tillers (1.90/plant), grain yield (2198 kg/ha), stover yield (4216 kg/ha) and productivity (26.5 kg/day) were obtained with sowing at 1st July as compared to sowing on 1st August however, it was statistically at par with sowing at 1st April. In contrast, Maximum net returns (Rs. 59955/ha), B:C ratio (3.63) and profitability (Rs. 722/day) were obtained with sowing 1st July. The maximum grain yield (2432 kg/ha) and stover yield (4496 kg/ha) was recorded with application of atrazine (PE) @ 500 g a.i. /ha + one hoeing through tractor operated weeder at 30 DAS, which was statistically at par with twice hoeing at 15 and 30 days after sowing over weedy check. Application of atrazine (PE) @ 500 g a.i. /ha + one hoeing through tractor operated weeder at 30 DAS followed by application of Atrazine @ 400 g a.i. /ha at 15 DAS was obtained maximum net returns (Rs. 66443/ha), B:C ratio (3.85) and profitability (Rs. 837/day).

Key words : Pearl millet, productivity, profitability, tractor operated weeder, weed control efficiency.

Pearl millet (*Pennisetum glaucum* L.) is a unique crop among the major cereals and the staple food and fodder crop of the world's poor and most food insecure populations in the arid and semi-arid tropics (Chaudhary *et al*., 2018). It is one of the major millet crops in India that thrives well even under adverse weather conditions (Kumar *et al*., 2012; Arya *et al*., 2014). India is the largest producer of pearl millet with an annual production of 8.61 million tonnes from an area of 6.93 million hectare and productivity of 1243 kg/ha (Anonymous, 2020). Rajasthan ranks first in area 4.29 million hectare and production 5.11 million tonnes with productivity 1192 kg/ha (Anonymous, 2019-20). In India, Rajasthan tops the list and Maharashtra is in second position. Pearl millet cultivation is dispersed mainly during *kharif* (Rainy) season across the country.

The various agronomic practices such as planting time, spacing, seed rate, application of fertilizer, irrigation and weed management play an important role in maximizing the production of pearl millet. Optimum planting time is a main factor influencing the seed production of pearl millet (Jan *et al*., 2015). Sowing date of pearl millet, either early or late, affects the final yield. Optimum sowing date of millet offers improved productivity (Khan *et al*., 2009), sufficient duration of vegetative growth, efficient consumption of soil nutrient & radiation energy and adequate reproductive growth (Solar *et al*., 2008). For better productivity of pearl millet, optimization of suitable sowing time assured less weed crop competition and increase productivity (Arslan *et al*., 2018).

Weed is one of the major barriers responsible for low pearl millet productivity, as weeds are competing with the crop for moisture, nutrients, space and light. They also increase the cost of production, harbour insect-pest and plant disease, and decrease product quality. The critical period for weed competition in pearl millet is up to 30-45 days after sowing (Bhan *et al.,* 1998). Timely weed control

practices assured less weed crop competition and increased productivity. The performance of pearl millet sown on 30th June under two hand hoeings at 15 and 30 DAS for weed control was found superior in terms of the grain yield per ha compared with the other treatments (Arslan *et al*., 2018). However, neither herbicides nor mechanical cultivation were adequate for consistent and acceptable weed control. Under such circumstances, keeping in consideration the importance of sowing dates and weed control practices the present field experiment was planned to discover the most appropriate weed management strategy and sowing date for better yield and yield attributes of pearl millet.

MATERIALS AND METHODS

Experimental site, soil and Climate characteristics

A field experiment was conducted at farm of Agricultural Research Station, Mandor, Jodhpur (26°21′9″ N latitude, 73°2′41″ E longitude and 231 m altitude) during the *kharif/summer*, 2018 & 2019. Jodhpur region comes under Arid Western Plains Agro-Climatic Zone IA of Rajasthan and Western dry Region-XIV of India. However, based on Agro-ecological region this center comes under hot arid eco region with desert and saline soils. The onset of the south west monsoon over the eastern parts of the state is witnessed almost by the last week of June which extends over the entire state by the first week of July. The soil of the experimental site was sandy and its moderately calcareous and alkaline in reaction. This is poor in organic matter (0.14%), nitrogen (174 kg/ha), iron, zinc and medium in phosphorus (22.2 kg P_2O_5/ha) while, rich in potassium (325 kg K_2O/ha).

Treatments and experimental design

The experiment was designed using split plot design, replicated thrice. The factor of sowing dates (1st April,1st July and 1st August) was maintained in main plots, while sub-plot factor weed control practices comprising of weedy check (weeds were not controlled), twice hoeing at 15 and 30 days after sowing (DAS), weed control using herbicide *i.e.*, application of atrazine @ 400 g a.i. /ha at 15 DAS, one hoeing through tractor operated weeder at 20 DAS and application of atrazine (PE) @ 500 g a.i. /ha + one hoeing through tractor operated weeder at 25 DAS. Experimental plot net size was 50 × 18 m and 45 total experimental units.

Crop establishment and management

Seed of pearl millet (variety MPMH 17) was obtained from ARS, Mandor (AU Jodhpur). Line sowing was done after field preparation using seed rate 5 kg/ha after treating the seed with chlorpyriphos 20 EC @ 4 ml/kg. Planting geometry was 45 cm apart row to row while maintaining 15 cm plant to plant distance. Layout of experiment allowed cultural practices and irrigation application on each sowing date independently. Pearl millet crop was given a uniform application of recommended dose of 40 kg N/ha from urea and 20 kg P_2O_5/ha from di-ammonium phosphate. Whole dose of P_2O_5 and half dose of nitrogen were drilled uniformly before sowing through di-ammonium phosphate and remaining nitrogen through urea, respectively in individual plot at the depth of 7 to 8 cm below the seed. The remaining N dose was applied in one split dose through broad casting at 25-30 days after sowing (DAS).

Data Collection and Statistical Analysis

Data regarding growth and yield parameters of pearl millet were collected according to standard procedures. Data regarding weed parameters were collected using 0.5 m^2 quadrate from two spots in each plot of treatment. Pre-harvest data *i.e.,* plant height, stem diameter, leaf area per plant (cm^2) and fresh weight of leaves (g/plant); while, post-harvest data *i.e.,* number of grains/head, 1000 grain weight (g) and grain yield (kg/ha) with respect to each treatment were recorded. The experimental observations on weeds as like weed flora, weed density, weed dry matter, weed control efficiency and weed index. Weeds were identified as per treatment, counted, then sun dried after clipping off at the soil surface and oven dried wrapping in craft paper at 70 °C till constant weight. Weed indices *i.e.,* weed control efficiency (WCE) and weed index (WI) were worked out to assess the efficiency of different weed control treatments by using the formulae suggested by Mishra and Mishra (1997) and Raju (1998).

The statistical analysis was done using Fisher's analysis of variance technique and least significant difference test at 5% level of significance to compare significance of the differences between treatments (Panse and Sukhatme 1985). The data of weed density and weed dry weight were subjected to square root transformation $\sqrt{(x+0.5)}$ to normalize their distribution as per Gomez and Gomez (1984). Where, x is the

original data. The data were statistically analyzed and pooled data of two years were presented.

RESULTS AND DISCUSSION

The major weed species observed in the experimental plot were grassy weeds like *Cynodon dactylon*, *Brachiaria eruciformis*; broad-leaf weeds like *Parthenium hysterophorus*, *Commelina benghalensis*, *Celosia argentea*, *Panicumi sachmi*, *Amaranthus viridis*, *Euphorbia microphylla*, *Phyllanthus niruri*, *Alteranthera triandra*; and sedges like *Cyperus rotundus etc*.

Effect on weed density, fresh weight of weeds, dry weight of weeds, weed control efficiency and weed index

Different sowing dates showed significant (p= 0.05) effects on weed density, fresh weight and dry weight of weeds at harvest stage (Table 1). The weed density (44.5/m^2), fresh weight (161 g/m^2) and dry weight of weeds (39.9 g/m^2) at harvest in pearl millet were significantly lower with 1st April over 1st July, which was statistically at par with 1st August. It is grown during *kharif* and *summer* season but it grown predominantly in *kharif* season, weeds of different kinds deprive the crop. Because of wider row spacing and slow initial growth in pearl millet, weeds are more problematic during initial crop growth period in *kharif/* rainy season due to availability of favorable climatic conditions. The similar results were also reported by Chaudhary *et al*. (2018).

Weed control practices significantly affected weed density, fresh weight and dry weight of weeds, weed control efficiency (WCE) and weed index (WI)as compared with weed check (Table 1). The weed density (15.8/m^2), fresh weight (58.8 g/m^2) and dry weight of weeds (12.0 g/m^2) at harvest in pearl millet were significantly lower with twice hoeing at 15 and 30 DAS compared other treatments but it was statistically at par with application of atrazine (PE) @ 500 g a.i. /ha + one hoeing through tractor operated weeder at 25 DAS. The highest WCE was 90.7% with twice hoeing at 15 and 30 DAS followed by (89.0%) application of atrazine (PE) @ 500 g a.i. /ha + one hoeing through tractor operated weeder at 25 DAS and lowest in weed check. WI is an indicator of reduction in grain yield due to weeds was lowest with application of atrazine (PE) @ 500 g a.i. /ha + one hoeing through tractor operated weeder at 25 DAS followed by twice hoeing at 15 and 30 DAS. While, weedy check treatment recorded the highest WI (49.5%) among all the treatments. Furthermore, weed

TABLE 1

Effect of sowing dates and weed control practices on weed density, fresh weight of weeds, dry weight of weeds, weed control efficiency and weed index at harvest in pearl millet

Treatments	Weed density (nos./m^2)	Fresh weight of weeds (g/m^2)	Dry weight of weeds (g/m^2)	Weed control efficiency (%)	Weed index (%)
Sowing dates					
1st April	44.5 (6.71)	161.0 (12.71)	39.9 (6.35)	-	-
1st July	62.1 (7.91)	192.9 (13.91)	43.4 (6.63)	-	-
1st August	54.7 (7.43)	176.9 (13.32)	36.9 (6.12)	-	-
SEm ±	2.1 (1.61)	5.39 (4.15)	1.5 (1.40)	-	-
CD (P=0.05)	8.2 (2.94)	21.18 (4.64)	5.7 (2.49)	-	-
Weed control practices					
Weedy check/Control	129.9 (11.42)	533.4 (23.11)	128.4 (11.35)	0.0	49.5
Twice hoeing at 15 and 30 DAS	15.8 (4.04)	58.8 (7.70)	12.0 (3.53)	90.7	4.2
Application of Atrazine @ 400 g a.i. /ha at 15 DAS	41.7 (6.50)	86.4 (9.32)	17.8 (4.28)	86.1	14.2
One hoeing through tractor operated weeder at 20 DAS	53.1 (7.32)	135.8 (11.68)	28.0 (5.34)	78.2	18.1
Application of Atrazine (PE) @ 500 g a.i. /ha + one hoeing through tractor operated weeder at 25 DAS	28.2 (5.36)	70.4 (8.42)	14.1 (3.82)	89.0	0.0
SEm ±	10.3 (3.28)	32.80 (7.68)	8.6 (3.02)	-	-
CD (P=0.05)	29.9 (5.52)	95.74 (13.08)	25.2 (5.07)	-	-

Figures in the parenthesis are original values. All figures are subjected to transformed values to square root √(x + 0.5).

control practices showed significantly lower weed-crop competition due to low density, dry matter of weeds and higher WCE. The similar results were also reported by Arslan *et al*. (2018). This might be due to effective control of first flush of weeds by atrazine and subsequent flushes by hand weeding. Results are similar as earlier finding of Bhuva and Detroja (2018) and Samota (2019). In the light of literature reviewed, present findings are in conformity with the results obtained by Sangwan *et al*. (2018) on dual purpose wheat crop.

Effect on growth attributes, yield attributes and yield of pearl millet

Growth attributes of pearl millet were significantly affected by different date of sowing (Table 2). Plant height (155.6 cm), stem diameter (1.28 cm), dry matter at 30, 60 DAS & at harvest (59.0, 425.3 and 641 g/m^2), leaf area index (LAI) at 40 and 60 DAS (3.61 and 5.62) were significantly higher with 1st July over 1st August which was statistically at par with1st April (Fig. 1). Yield attributes *i.e.,* number of effective tillers, ear head length, test weight of pearl millet were significantly higher with 1st July over 1st August which was statistically at par with1st April. Grain yield was significantly higher with 1st July (17.04%) over 1st August but it was statistically at par with 1st April (Table 3). Similar trend found in stover yield which was significantly higher with 1st July (15.79 %) over 1st August. Harvest index and productivity of pearl millet were recorded non-significant in all sowing dates. The similar results were also reported by Arslan *et al*. (2018). Optimum planting time is a chief factor influencing the seed production of pearl millet (Jan *et al*., 2015). Sowing date of pearl millet, either early or late, affects the final yield. Because, optimum sowing date of millet offers increased productivity due to sufficient duration of vegetative growth, efficient consumption of soil nutrient and radiation energy and adequate reproductive growth (Khan *et al*., 2009). In the light of literature reviewed, present findings are in conformity with the findings obtained by Koireng *et al*. (2018) on fodder maize under rainfed condition.

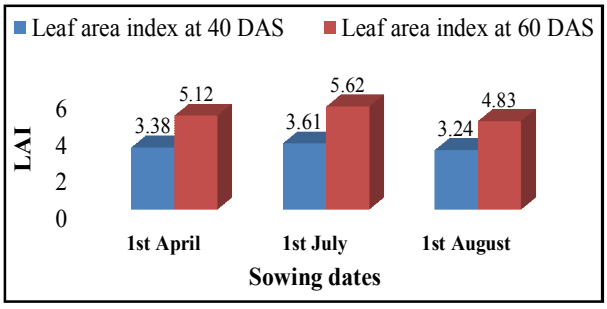

Fig. 1. Influence of sowing dates on Leaf area Index at 40 and 60 DAS of pearl millet.

Growth attributes of pearl millet *i.e.,* plant height (174.5 cm), stem diameter (1.37 cm), dry matter at 30, 60 DAS & at harvest (431.0, 431.0 and 692.8 g/m^2), leaf area index at 40 and 60 DAS (3.70 and 5.52) were significantly higher with application of atrazine (PE) @ 500 g a.i. /ha + one hoeing through tractor operated weeder at 25 DAS as compared to weedy check (Table 2 & Fig. 2). Yield attributes *i.e.,* number of effective tillers (1.99/plant), ear head length (27.4 cm), test weight (7.33 g) of pearl millet (Table 3) were significantly higher with application of atrazine (PE) @ 500 g a.i. /ha + one hoeing through tractor operated weeder at 25 DAS compared weedy check. Grain yield was significantly higher (96.9%) with application of atrazine (PE) @ 500 g a.i. /ha + one hoeing through tractor operated weeder at 25 DAS over weedy check, one hoeing through tractor operated weeder at 20 DAS and application of Atrazine @ 400 g a.i. /ha at 15 DAS but it was statistically at par with twice hoeing at 15 & 30 DAS and similar trend found in stover yield. Harvest index was significantly higher with application of atrazine (PE) @ 500 g a.i. /ha + one hoeing through tractor operated weeder at 25 DAS over weedy check. Productivity of pearl millet was significantly 92.3% higher compared weedy check but which was statistically at par with all rest of treatments. The similar results were also reported by Arslan *et al*. (2018). Grain yield and yield attributes were recorded higher with pre-emergence application of atrazine 0.5 kg/ha + 1 HW at 35 DAS and increased the yield by 62.14% over weedy check (Girase *et al*., 2017).

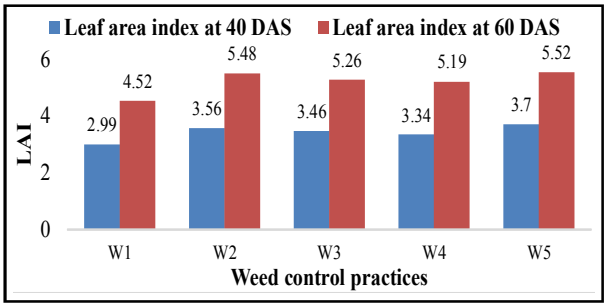

Fig. 2. Influence of weed control practices on Leaf area Index at 40 and 60 DAS of pearl millet. Where, W1 = Weedy check/Control, W2 =Twice hoeing at 15 and 30 DAS, W3 = Application of Atrazine @ 400 g a.i. /ha at 15 DAS, W4 = One hoeing through tractor operated weeder at 20 DAS, W5 = Application of Atrazine (PE) @ 500 g a.i. /ha + one hoeing through tractor operated weeder at 25 DAS.

TABLE 2
Effect of sowing dates and weed control practices on growth attributes of pearl millet

Treatments	Plant height (cm)	Stem diameter (cm)	Dry matter (g/m^2) at 30 DAS	Dry matter (g/m^2) at 60 DAS	Dry matter (g/m^2) at harvest
Sowing dates					
1st April	142.1	1.17	53.4	383.8	580.3
1st July	155.6	1.28	59.0	425.3	641.5
1st August	134.5	1.09	50.5	364.4	551.9
SEm ±	4.8	0.05	2.0	13.3	21.1
CD (P=0.05)	18.9	0.18	7.8	52.1	82.8
Weed control practices					
Weedy check/Control	81.2	0.74	39.1	304.0	404.6
Twice hoeing at 15 and 30 DAS	174.7	1.34	60.1	435.3	672.3
Application of Atrazine @ 400 g a.i. /ha at 15 DAS	149.7	1.24	56.1	401.4	585.7
One hoeing through tractor operated weeder at 20 DAS	140.2	1.20	54.1	384.4	600.7
Application of Atrazine (PE) @ 500 g a.i. /ha + one hoeing through tractor operated weeder at 25 DAS	174.5	1.37	62.2	431.0	692.8
SEm ±	9.6	0.09	3.3	18.5	28.9
CD (P=0.05)	27.9	0.27	9.8	54.1	84.5

TABLE 3
Effect of sowing dates and weed control practices on yield attributes and yield of pearl millet

Treatments	No. of effective tillers/plant	Ear head length (cm)	Test weight (g)	Grain yield (kg/ha)	Stover yield (kg/ha)	Harvest Index (%)	Productivity (kg/day)
Sowing dates							
1st April	1.72	24.9	6.79	1988	3815	33.8	26.5
1st July	1.90	27.5	7.50	2198	4216	33.8	26.5
1st August	1.62	23.6	6.42	1878	3641	33.5	23.5
SEm ±	0.06	0.85	0.23	69.49	132	0.3	1.0
CD (P=0.05)	0.23	3.33	0.91	272.84	517	NS	NS
Weed control practices							
Weedy check/Control	1.33	21.7	5.82	1235	2811	27.7	15.6
Twice hoeing at 15 and 30 DAS	1.91	26.9	7.29	2341	4382	35.3	29.5
Application of Atrazine @ 400 g a.i. /ha at 15 DAS	1.81	25.7	6.96	2097	3760	36.7	26.5
One hoeing through tractor operated weeder at 20 DAS	1.70	25.0	7.13	2002	4005	32.9	25.2
Application of Atrazine (PE) @ 500 g a.i. /ha + one hoeing through tractor operated weeder at 25 DAS	1.99	27.4	7.33	2432	4496	35.6	30.7
SEm ±	0.08	1.19	0.32	96.53	185	1.3	1.6
CD (P=0.05)	0.24	3.49	0.95	281.74	539	3.9	4.6

Effect on economics of pearl millet

The effectiveness of any technology (sowing dates and weed control practices) especially in pearl millet production is based on its economics. Economic analysis is the primary consideration to determine which treatment gives highest net returns (Table 4). Economic analysis showed that sowing of pearl millet at 1st july was the most economical treatment with highest net returns (Rs. 59955/ha), productivity (Rs. 722/day) maximum benefit cost ratio (BCR) followed by showing at 1st April. The similar findings were also reported by Arslan *et al*. (2018), Koireng *et al*. (2018) and Girase *et al*. (2017).

Application of Atrazine (PE) @ 500 g a.i. /ha + one hoeing through tractor operated weeder at 25

TABLE 4
Effect of sowing dates and weed control practices on economics of pearl millet

Treatments	Cost of cultivation (Rs./ha)	Net returns (Rs./ha)	B : C ratio	Profitability (Rs./day)
Sowing dates				
1st April	18144	51310	2.88	684
1st July	16824	59955	3.63	722
1st August	17304	48557	2.86	607
SEm ±	-	-	-	-
CD (P=0.05)	-	-	-	-
Weed control practices				
Weedy check/Control	13960	32268	2.32	407
Twice hoeing at 15 and 30 DAS	24680	56325	2.29	709
Application of Atrazine @ 400 g a.i. /ha at 15 DAS	15440	55973	3.64	706
One hoeing through tractor operated weeder at 20 DAS	15720	55360	3.53	697
Application of Atrazine (PE) @ 500 g a.i. /ha + one hoeing through tractor operated weeder at 25 DAS	17320	66443	3.85	837
SEm ±	-	-	-	-
CD (P=0.05)	-	-	-	-

DAS was highly economical weed control practice with highest net returns (Rs. 66443/ha), productivity (Rs. 837/day) maximum benefit cost ratio (BCR). However, lowest net returns (Rs. 66443/ha) and productivity (Rs. 407/day) were obtained in weedy check. The similar results were also reported by Nadeem *et al*. (2013), Sangwan *et al*. (2018) and Arslan *et al*. (2018).

CONCLUSIONS

The major aim of this study was to evaluate the impacts of sowing dates and weed control practices on productivity and profitability of pearl millet in Rajasthan. Based on the present finding it is concluded that maximum productivity and probability of pearl millet can be obtained by sowing date at 1st July with weed control practice through application of Atrazine (PE) @ 500 g a.i. /ha + one hoeing through tractor operated weeder at 25 DAS.

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