Scientific Research Publishing

American Journal of Plant Sciences, 2018, 9, 1974-1986
http://www.scirp.org/journal/ajps
ISSN Online: 2158-2750
ISSN Print: 2158-2742

# Weed Control Practices and Varying Sowing Dates Effects on Seed Production of Pearl Millet (*Pennisetum americanum* L.) under Semi-Arid Environment

**Naveed Arslan[1], Usman Zulfiqar[1], Muhammad Ishfaq[1*], Muhammad Ahmad[1], Muhammad Nabeel Anwar[1], Azeem Ullah[1], Iqra Nazar[2], Asif Iqbal[1], Muhammad Zohaib Anjum[3]**

[1]Department of Agronomy, University of Agriculture, Faisalabad, Pakistan
[2]Department of Botany, University of Agriculture, Faisalabad, Pakistan
[3]Department of Forestry and Range Management, University of Agriculture, Faisalabad, Pakistan
Email: *ishfaq2727@gmail.com

**How to cite this paper:** Arslan, N., Zulfiqar, U., Ishfaq, M., Ahmad, M., Anwar, M.N., Ullah, A., Nazar, I., Iqbal, A. and Anjum, M.Z. (2018) Weed Control Practices and Varying Sowing Dates Effects on Seed Production of Pearl Millet (*Pennisetum americanum* L.) under Semi-Arid Environment. *American Journal of Plant Sciences*, **9**, 1974-1986.
https://doi.org/10.4236/ajps.2018.99143

**Received:** July 16, 2018
**Accepted:** August 28, 2018
**Published:** August 31, 2018



## Abstract

Peral millet being drought tolerant has substantial potential to contribute in food security ensuring the food, fodder and nutritional value in different Asian and African countries. Susceptibility to abiotic and biotic factors and low productivity are the main reasons for decreasing productivity and area of millets. In this context, evaluation of the effect of weed control practices and varying sowing dates on grain yield of kharif season grown pearl millet (*Pennisetum americanum* L.) was demonstrated at post graduate agriculture research station, University of Agriculture, Faisalabad during 2015. Forage pearl millet was sown at three different sowing dates *i.e.* mid-June, end of June and mid-July and four weed control practices viz. weedy check (no weeding), twice hoeing at 15 and 30 days after sowing (DAS), weed control using herbicides *i.e.* application of Atrazine (Awax 38 SC) @ 330 g a.i. $ha^{-1}$ at 15 DAS, and twice foliar applications of 10% Sorghum water extract (Sorgaab) (at 15 and 30 DAS). The experiment was laid out in randomized complete block design (RCBD) under split plot arrangement, comprising of three replications. The treatments with varying sowing dates were randomized in main plots and weed control practices were in subplots. Results showed that the highest plant height (279.51 cm), leaf area (2777.80 $cm^2$), fresh weight of leaves per plant (155.57 g), maximum number of grains per head (3162.0) and grain yield (3419.7 $kg{\cdot}ha^{-1}$) were obtained in the treatment combination of 30th June sowing × twice weed hoeing (at 15 and 30 DAS) while, maximum 1000-grain weight (8.45 g) was observed in treatments where weeds were controlled by hoeing (at 15 and 30 DAS). Moreover, cultural weed con-

trol practices reduce significantly weed density, fresh and dry Wight of weeds. In sum, it is concluded that to reduce the weed-crop competition and to gain higher productivity of pearl millet, field should be weed free 20 - 45 days after sowing.

## Keywords

Sowing Dates, Weed Control Methods, Herbicide, Grain Yield, Pearl Millet

## 1. Introduction

Forage crops are getting important in agriculture and total area in Pakistan (Punjab) under forage crops in 2010 was 5.48 million hectares. A total of 3.46 million tones forage production was recorded by national agencies with an average productivity of 420 kg·ha$^{-1}$ in Khyber Pakhtunkhwa [1]. Forage crops are the cheapest and main source of feed in Pakistan. Amongst various forage crops pearl millet (*Pennisetum americanum* L.) is the important forage and locally called as Bajra. It ranked third most important fodder crop among live stock feeds [2]. Millet is $C_4$ crop and high temperature receptive crop, which requires optimum moisture for higher productivity [3].

Current forage production is still insufficient in fulfilling the national demand for forage. One of the most important limiting factors for livestock business is shortage of fodder crop. Moreover, poor quality production of forage and seasonal shortage of forage during extreme winter as well in summers and 2.5% decrease in area under forage per decade are key constraints for forage and livestock production [3]. Low production of forages is primarily due to unavailability of proper land for forage production, improper sowing time and techniques, unavailability of high quality forage seeds, poor irrigation and nutrition management, weed infestation and poor plant protection etc. Very little research has been done on forage production so far, especially in relation to development of new varieties, so there is major dependence on imported seed for forage production. Farmers rely on their own produced seeds in spite of its low yield potential [4].

Under favorable conditions millet has capability to attain height of 6 - 10 feet [5]. Millet is normally cultivated for various purposes, viz. grain crop, hay, fuel, fodder and due to its nutritious importance, it is recommended for use as livestock feed [6]. Optimum planting time is a chief factor influencing the seed production of pearl millet [7]. Sowing date of pearl millet, either early or late, affects the final yield. Optimum sowing date of millet offers increased productivity [8], sufficient duration of vegetative growth, efficient consumption of soil nutrient and radiation energy and adequate reproductive growth [9]. For better productivity of pearl millet, optimization of suitable planting time is prerequisite [10].

Weeds affect the crop productivity, as they create competition during early growth stages for resources with crop plants and limits the yield and quality of

pearl millet [11]. Reduction in yield due to weeds infestation is up to 35% [12]. Irregular and uneven stand establishment lead to decrease in the grain yield. Optimum planting time is a handy tool to control weed infestation by providing prospects for crop plant and weeds to germinate concurrently [13]. Less research has been undergone so far, because there is a less emphasis on high quality forage and seed production of fodder crops. Under such circumstances, keeping in consideration the importance of weed management and sowing dates 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.

## 2. Materials and Methods

### 2.1. Experimental Location

To estimate the impact of varying sowing dates and different weed control techniques on pearl millet (*Pennisetum americanum* L.) forage production, an experiment was conducted during 2015 at post agriculture research station, University of Agriculture, Faisalabad (31.35-31.47˚N latitude, 72.08-73.0695˚E longitude and 183 m Altitude). Pre-planting soil sample from the experimental site was obtained using auger at 0 - 15 cm and 15 - 30 cm depth. Physico-chemical soil analysis was done in soil fertility laboratory, Ayub Agricultural Research Institute, Faisalabad and report is shown in Table 1. Soil type of the experimental site was sandy clay (medium hard). Moreover, meteorological data during the whole season of crop is presented in Figure 1.

### 2.2. Experimental Description and Treatments

The experiment was designed using Randomized Complete Block Design

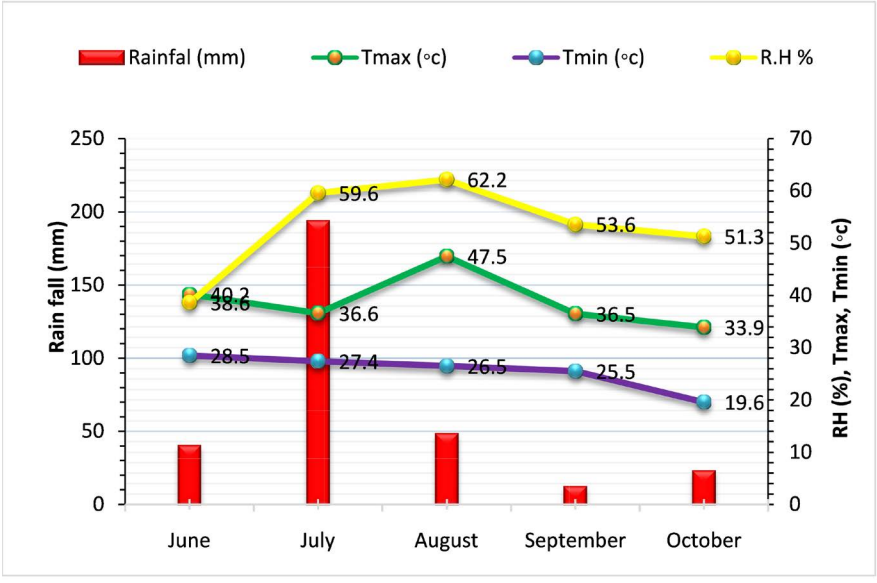


Figure 1. Meteorological data for cropping season (2015) University of Agriculture, Faisalabad.

**Table 1.** Physical and chemical properties of experimental site.

| Determination | Unit | Value obtained |
|---|---|---|
| Sand | % | 64 |
| Silt | % | 17.6 |
| Clay | % | 18.4 |
| EC | $dSm^{-1}$ | 1.56 |
| pH | | 7.9 |
| Organic matter | % | 0.89 |
| Total N | % | 0.31 |
| Available phosphorous | ppm | 5.28 |
| Available K | ppm | 187 |

(RCBD) with split plot arrangement, replicated thrice. The factor of sowing dates ($SD_1$ = 15th June, $SD_2$ = 30th June and $SD_3$ = 15th July) was maintained in main plots, while sub-plot factor weed control techniques (W) comprising of $W_1$ = Weedy check (weeds were not controlled), $W_2$ = Weed control with 2 hoeing at 15 and 30 days after sowing (DAS), $W_3$ = Herbicidal weed control method using Atrazine (Awax 38 SC) @ 330 g a.i $ha^{-1}$ applied at 15 DAS, and $W_4$ = 10% Sorghum water extracts sprayed at 15 and 30 DAS. Experimental plot net size was 8.0 m × 3.6 m. Total experimental units were 36.

## 2.3. Experimental Procedure

Seed of pearl millet (variety MB-87) was obtained from Maize & Millets Research Institute-Yusafwala (Sahiwal). Ridge sowing was done after seed bed preparation (making ridges) using seed rate 8 $kg{\cdot}ha^{-1}$ after treating the seed with Chloropyriphos @ 4 $ml{\cdot}kg^{-1}$. Planting geometry was 60 cm apart ridges while maintaining 15 cm plant-plant distance. Water extract of sorghum (Sorgaab) has potential to reduce the infestation of weeds species like, *Chenopodium album*, *Cyperus rotundus*, *Phalaris minor*, *Rumex dentatus* and *Senebiera didyma* have been observed due to its allelopathic role by releasing allelochemical as "sorgeolone" [14]. Sorghum sticks were harvested at maturity and dried under shade. Well dried plants stalks chopped using fodder chopper and oven dried at 70˚C for 72 hours to gain constant weight. Then crushed in a grinder and passed through sieve of 40 mm. Soaked in distilled water for one day at room temperature using 1 g herbage and 20 ml water ratio as directed by Cheema and Khaliq, [15]. Water extract (sorgaab) was gained by sieving the mixture (herbage and water) through a Whatman # 42 filter paper. The required concentration was made by diluting the extract. Layout of experiment allowed cultural practices and irrigation application on each sowing date independently. Standard dose of fertilizer NP @ 140:60 $kg{\cdot}ha^{-1}$ was applied uniformly in all experimental plots. Whole phosphorus (DAP) and 50% dose of nitrogen (Urea) was applied immediately at the time of sowing while, remaining 50% of nitrogen was applied at

jointing stage.

### 2.4. Data Collection and Statistical Analysis

Data regarding growth and yield parameters of pearl millet were collected according to standard procedures. Five plants from each treatment and replication were randomly selected and observation was recorded. Pre-harvest data -plant height, stem diameter, Leaf area per plant ($cm^2$) and fresh weight of leaves (g $plant^{-1}$); while, post-harvest data -number of grain $head^{-1}$, 1000-grain weight (g) and grain yield ($kg{\cdot}ha^{-1}$) at 90 DAS with respect to each treatment were recorded. Data regarding weed parameters were collected using 0.5 $m^2$ quadrate from two spots in each treatment. As per treatment weeds were identified, counted and then sun-dried after clipping off at soil surface, oven dried wrapping in craft paper at 70 C till constant weight. The statistical analysis was done using Fisher's analysis of variance technique and least significant difference (LSD) test at 5% level of significance to compare significance of the differences between treatments [16].

## 3. Results and Discussion

Data presented in **Figure 2(a)** and **Figure 2(b)** shows that sowing dates, techniques to control weeds and interaction of both factors significantly influenced the plant height and stem diameter of pearl millet. The highest plant height (279.51 cm) followed by (267.30 cm) were observed where sowing was done on 30th June and 15th June respectively, maximum stem thickness (1.36 cm) followed by (1.32 cm) were observed in plots where sowing was done on 15th June and 30th June respectively and weed control practice $W_2$ (twice hoeing *i.e.* at 15 and 30 DAS) was used. While, the least plant height (170.16 cm) and stem thickness (0.83 cm) were recorded in weedy check plots and sowing was done on 15th July. Reasons behind higher plant height and stem thickness in first two sowing dates may be the long duration from planting to maturity, more photosynthesis that resulted in more photosynthetic assimilate accumulation, which ultimately increased vegetative growth. The results of our experiment are in accordance with the results of Arif *et al.* [17], Mass *et al.* [18] and Siddig *et al.* [19]; they explained that more tallness in plant height and thickness of stem are due to early planting of crops as equated to late planting.

Proper and timely weed control as well as timely sowing reduced crop-weed competition, made possible for crop to acquire input resources efficiently and ultimately resulted in better growth [20] [21]. In contrast, late sowing, due to photoperiodism influenced the crop to change its mode of growth from vegetative to reproductive, shortened the vegetative growth period and significantly reduced the plant height and thickness of the stem. Our results regarding thickness of stem are contradictive with the results of Wailare [22]. He claimed that stem thickness could not be significantly changed due to changing sowing dates. However, our results are also advocated by the finding of Shinde *et al.* [23], in

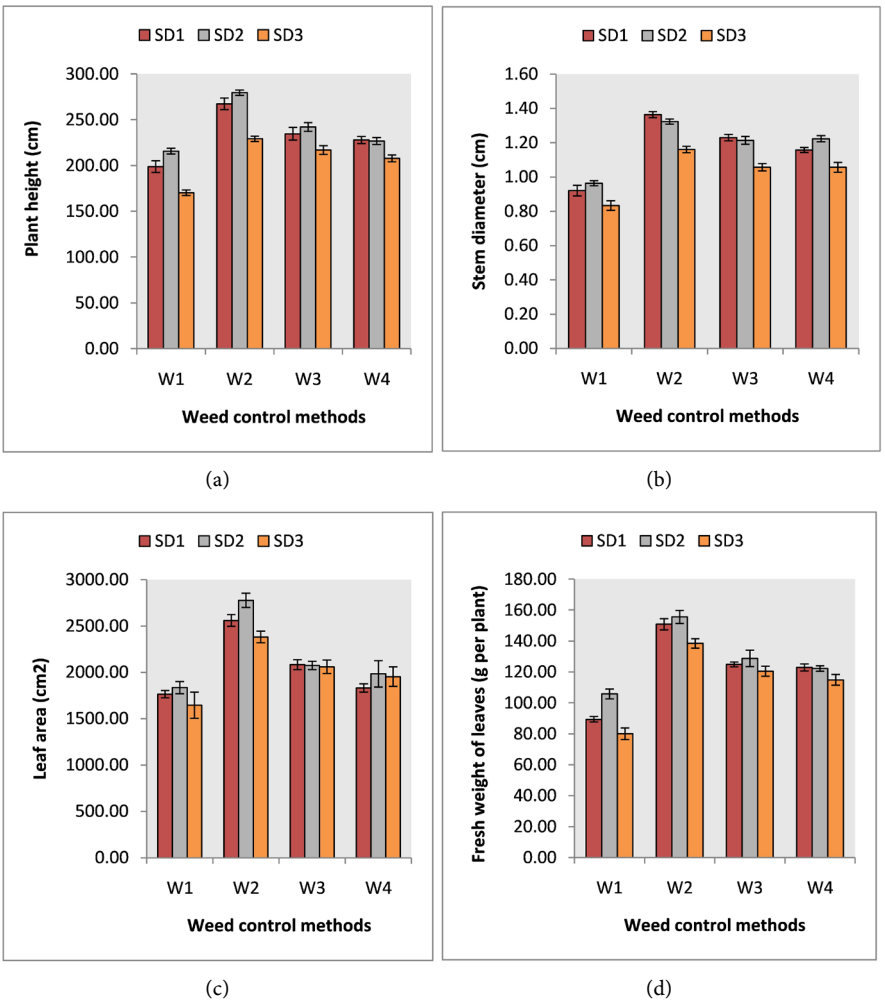


**Figure 2.** Influence of sowing dates and different weed control techniques on (a) plant height; (b) stem diameter; (c) Leaf area per plant ($cm^2$) and (d) fresh weight of leaves (g $plant^{-1}$) of pearl millet (*Pennisetum americanum* L.). Where $SD_1$ = 15th June, $SD_2$ = 30th June, $SD_3$ = 15th July, $W_1$ = Control, $W_2$ = Cultural practices (2 hoeing at 15 and 30 DAS), $W_3$ = Chemical method (Atrazine (Awax 38 SC) @ 330 g a.i $ha^{-1}$ at 15 DAS), $W_4$ = Sorghum water extract (Sorgaab) 10% (1 sprays at each 15 and 30 DAS).

which it was noticed that full weed suppression in crop increased the plant height and stem thickness as weed crop competition reduced. Delayed sowing and more weed crop competition resulted in poor crop stand, weak and lean seedling and stunted growth of crop because weeds compete with the crop plants for resources like sunlight, nutrients, space and water [24]. Asseng *et al.* [25] and Jan *et al.* [7] also stated that delaying the planting badly affect the number of leaves $plant^{-1}$ and leaf area index. Similarly, Nalewaja *et al.* [26] reported that plant height and thickness of stem significantly increased when we follow the proper weed control practices to reduce weed infestation and crop weed competition.

Influence of planting dates and different weed management strategies on leaf area and leaves fresh weight is showed in **Figure 2(c)** and **Figure 2(d)** Data in-

dicate that sowing dates, weed control techniques and their interaction significantly influenced these parameters of pearl millet. Data indicate that pearl millet sown on 15th June and 30th June gained more leaf area and fresh weight of leaves as compared to sowing on 15th July. The highest (2777.8 $cm^2$) leaf area (**Figure 2(c)** and leaves fresh weight (**Figure 2(d)** (155.57 g) was obtained from plots where pearl millet was sown on 30th June and weeds were controlled using $W_2$ (Cultural practices: 2 hoeing at 15 and 30 DAS) technique. In contrast, least leaf area (1644.84 $cm^2$) and fresh leaves weight (80.03 g) was noted in plots where sowing was done on 15th July under $W_1$ (weedy check) treatments. The highest leaf area and fresh weight of leaves in plots where sowing was done on 30th June and weed control practice was $W_2$ treatment were due to less weed-crop competition, prolong crop duration as compared to other treatments and more effective rainfall water. While, in $W_1$ treatments short duration of crop and more weed infestation suppressed the crop performance drastically. Our findings are in accordance with the results of Asseng *et al.* [25] and Eshraghi*et al.* [27]. According to their results sowing dates have significant effect on crop performance. More weeds flourish rapidly and compete with crop more effectively, reduce crop plant height, leaf area, dry matter accumulation and biological yield. Maqbool *et al.* [28] concluded that leaf area and fresh weight are severely affected due to more weed-crop competition as compared to weeds free planting. Moreover, water use efficiency, heliothermal use efficiency and heat use efficiency were also maximum in early planted pearl millet [29].

Data presented in **Table 2** showed that varying planting dates and weed control strategies significantly affected the total grains number in a head, test weight and grain productivity of pearl millet whereas the interaction of sowing dates and weed control practices for number in a head and grain productivity was significant. Date represented in **Table 3** highest grains per head (2545.6), 1000-grain weight (7.54 g) and grain yield (2934.8 $kg{\cdot}ha^{-1}$) were observed when pearl millet was planted on 30th June, while, the 3rd sowing date 15th July gave lowest values of yield components. Under the weed control treatments tested, the cultural practices $W_2$ (2 hoeings at 15 and 30 DAS) provided highest number of grains per head (2942.2), 1000-grain weight (8.45 g) and overall grain yield was (3176.6 $kg{\cdot}ha^{-1}$), while lowest grains per head of pearl millet, 1000-grain weight and grain yield (1815.0, 6.39 g and 2301.4 $kg{\cdot}ha^{-1}$) were obtained on the plots where weeds were not controlled ($W_1$). In case of interaction of sowing date and weed control practices $SD_2 \times W_2$ gave the highest grain per head (3162.0) and yield (3419.7), while lowest values for grain per head (1593.3) and yield (2137.0) were observed in $SD_3 \times W_1$ treatment (**Table 4**). Pearl millet sown on 30th June has obtained extended photoperiod that gave optimum environment for flowering, resulted in accumulation of more assimilates that leads to highest number of grains per head. These outcomes results are supported by the findings of Arif *et al.* [17] and Jan *et al.* [7]; they described that early sowing of pearl millet gave more number of grains per head compared with late sowing.

Highest number of grains per head in treatments where proper and timely weed management practiced resulted in reduced weed pressure and ultimately less weed-crop competition for nutrients, water and space. Results of this study were further in accordance with findings of Sharma and Jain [30] and Carson [12]. They concluded that optimum control of weeds increased the number of grains per head.

**Table 2.** The mean squares of influence of sowing dates and different weed control techniques on Weed density ($m^{-2}$), Fresh weight of weeds ($m^{-2}$), Dry weight of weeds ($m^{-2}$), Number of grain $head^{-1}$, 1000-grain weight (g) and grain yield ($kg{\cdot}ha^{-1}$) of forage peal millet (*Pennisetum americanum* L.).

| Source of variation | Df | Weed density ($m^{-2}$) | Fresh weight of weeds ($m^{-2}$) | Dry weight of weeds ($m^{-2}$) | Number of grain $head^{-1}$ | 1000-grain weight (g) | Grain yield ($kg{\cdot}ha^{-1}$) |
|---|---|---|---|---|---|---|---|
| **Replication (r)** | 2 | 18.7 | 572 | 36.5 | 79 | 0.07 | 437 |
| **Sowing Date (SD)** | 2 | 1416.0 | 6259 | 252.3 | 507,377** | 1.66 | 497,272** |
| **Error a** | 4 | 117.3 | 614 | 23.2 | 1324 | 0.24 | 1027 |
| **Weed Control (W)** | 3 | 68,855.1** | 583,760** | 23,196.4** | 2,036,328** | 6.79** | 1,268,685** |
| **SD × W** | 6 | 82.2 | 421 | 21.3 | 6696** | 0.08 | 14,246** |
| **Error b** | 18 | 138.6 | 353 | 14.2 | 463 | 0.11 | 1050 |
| **Total** | 35 | | | | | | |

** = Highly significant.

**Table 3.** Influence of sowing dates and different weed control techniques on Weed density ($m^{-2}$), Fresh weight of weeds ($m^{-2}$), Dry weight of weeds ($m^{-2}$), Number of grain $head^{-1}$, 1000-grain weight (g) and grain yield ($kg{\cdot}ha^{-1}$) of forage peal millet (*Pennisetum americanum* L.).

| Treatments | Weed density ($m^{-2}$) | Fresh weight of weeds ($m^{-2}$) | Dry weight of weeds ($m^{-2}$) | Number of grain $head^{-1}$ | 1000-grain weight (g) | Grain yield ($kg{\cdot}ha^{-1}$) |
|---|---|---|---|---|---|---|
| **Sowing date (SD)** | | | | | | |
| $SD_1$: (15th June) | 124.67 | 378.58 | 75.679 | $2392.0^b$ | 7.5150 | $2771.2^b$ |
| $SD_2$: (30th June) | 123.58 | 377.33 | 75.653 | $2545.5^a$ | 7.5483 | $2934.8^a$ |
| $SD_3$: (15th July) | 105.33 | 338.42 | 67.724 | $2138.3^c$ | 6.8892 | $2530.1^b$ |
| LSD (P = 0.05) | 12.28 | 28.07 | 5.46 | 1.25 | 0.56 | 36.33 |
| **Weed control (W)** | | | | | | |
| $W_1$: (Control) | $246.22^a$ | $742.33^a$ | $148.20^a$ | $1815.0^d$ | $6.3944^d$ | $2301.4^d$ |
| $W_2$: (Cultural practices) | $53.89^d$ | $288.22^b$ | $38.33^d$ | $2942.2^a$ | $8.4544^a$ | $3176.6^a$ |
| $W_3$: (Chemical method) | $73.22^c$ | $235.22^c$ | $47.43^c$ | $2483.2^b$ | $7.4322^b$ | $2892.8^b$ |
| $W_4$: (Sorghum water extract 10%) | $98.11^b$ | $288.22^b$ | $58.12^b$ | $2194.0^c$ | $6.9889^c$ | $2610.6^c$ |
| LSD (P = 0.05) | 11.66 | 18.60 | 3.73 | 21.30 | 0.32 | 32.09 |

Means sharing same letters did not differ significantly at P = 0.05; LSD = Least significant difference. $W_1$: Control (Without weeding); $W_2$: Cultural practices (twice hoeing, *i.e.* at 15 and 30 DAS); $W_3$: Chemical method (Atrazine Awax 38 SC) @ 330 g a.i $ha^{-1}$ at 15 DAS); $W_4$: Sorghum water extract 10% (twice sprays, *i.e.* at 15 and 30 DAS).

**Table 4.** Influence of sowing dates and different weed control techniques on Weed density ($m^{-2}$), Fresh weight of weeds ($m^{-2}$), Dry weight of weeds ($m^{-2}$), Number of grain $head^{-1}$, 1000-grain weight (g) and grain yield ($kg{\cdot}ha^{-1}$) of forage peal millet (*Pennisetum americanum* L.).

| Treatments | Weed density ($m^{-2}$) | Fresh weight of weeds ($m^{-2}$) | Dry weight of weeds ($m^{-2}$) | Number of grain $head^{-1}$ | 1000-grain weight (g) | Grain yield ($kg{\cdot}ha^{-1}$) |
|---|---|---|---|---|---|---|
| Interaction (SD × W) | | | | | | |
| $SD_1 \times W_1$ | 253.33 ± 8.8[(b)] | 749.67 ± 17.68 | 148.73 ± 4.06 | 1862.9 ± 13.54[h] | 6.4567 ± 0.16 | 2360.7 ± 14.99[g] |
| $SD_1 \times W_2$ | 60.67 ± 7.8 | 216 ± 13.10 | 43.37 ± 3.03 | 2994.3 ± 15.58[b] | 8.6 ± 0.44 | 3171.0 ± 19.84[b] |
| $SD_1 \times W_3$ | 76.67 ± 7.8 | 247.67 ± 13.53 | 49.82 ± 2.68 | 2453.7 ± 14.32[d] | 7.7333 ± 0.25 | 2923.7 ± 17.67[c] |
| $SD_1 \times W_4$ | 108 ± 7.4 | 301 ± 14.14 | 60.8 ± 2.55 | 2257.0 ± 16.31[f] | 7.27 ± 0.17 | 2629.3 ± 18.63[e] |
| $SD_2 \times W_1$ | 256.67 ± 11.4 | 771 ± 19.38 | 154.73 ± 2.80 | 1988.7 ± 18.79[g] | 6.62 ± 0.22 | 2406.7 ± 18.67[fg] |
| $SD_2 \times W_2$ | 53.67 ± 7.8 | 198.33 ± 18.14 | 39.33 ± 4.16 | 3162.0 ± 14.85[a] | 8.9 ± 0.35 | 3419.7 ± 16.62[a] |
| $SD_2 \times W_3$ | 79.33 ± 6.4 | 236.33 ± 14.32 | 47.89 ± 2.53 | 2674.3 ± 17.55[c] | 7.5133 ± 0.35 | 3150.0 ± 18.55[b] |
| $SD_2 \times W_4$ | 104.67 ± 6.4 | 303.67 ± 14.32 | 60.67 ± 2.23 | 2357.0 ± 18.75[e] | 7.16 ± 0.05 | 2762.7 ± 17.75[d] |
| $SD_3 \times W_1$ | 228.67 ± 9.2 | 706.33 ± 14.24 | 141.14 ± 4.01 | 1593.3 ± 10.80[i] | 6.1067 ± 0.14 | 2137.0 ± 18.43[h] |
| $SD_3 \times W_2$ | 47.33 ± 5.4 | 165.67 ± 6.98 | 32.28 ± 1.67 | 2670.3 ± 19.11[c] | 7.8633 ± 0.25 | 2939.0 ± 18.83[c] |
| $SD_3 \times W_3$ | 63.67 ± 5.5 | 221.67 ± 7.36 | 44.59 ± 1.86 | 2321.7 ± 19.90[e] | 7.05 ± 0.19 | 2360.7 ± 17.96[g] |
| $SD_3 \times W_4$ | 381.67 ± 8.9 | 260 ± 14.14 | 52.89 ± 2.70 | 1968.020.89[g] | 6.5367 ± 0.16 | 3171.0 ± 18.50[b] |
| LSD (P = 0.05) | 21.20 | 39.21 | 7.75 | 51.67 | 1.42 | 59.81 |

[(b)]the data are presented as the means ± SD; Means sharing same letters did not differ significantly at P = 0.05.

When pearl millet was planted on 30th June, it results in extended period for growth and development with ideal conditions and higher photosynthetic assimilation that ultimately translocated towards the seed attainment at physiological maturity resulting in higher grain weight as compared to the crop sown on 15th July. Siddig *et al.* [19] and Jan *et al.* [7] reported the similar results, and they stated that early planting of pearl millet improved the 1000-grain weight in comparison with late sown on 15th July. But these results were contradictory to Wailare [22], who stated that planting time have no substantial effect on 1000-grain weight of pearl millet. Weed control practices significantly increased test weight of pearl millet as compared to weedy check treatment due to vigorous growth and development that resultantly leads to higher assimilate accumulation in seeds. These results support the results of Kumar *et al.* [31].

Highest grain yield was recorded when pearl millet was planted on 30th of June, that proposes availability of suitable climatic conditions and prolonged growth period in comparison with late sown pearl millet. It was due to higher availability and accumulation of photosynthetic assimilates. Furthermore, weed control treatments significantly improved yield. Higher production under various weed control measures due to lower weed-crop competition, low density of weeds and appropriate accessibility of resources to pearl millet crop. These re-

sults substantiate the findings of Mass *et al.* [18] and Soler *et al.* [9]. They stated that significant increase in pearl millet yield was observed with early sowing. Similar results are also presented by Dahmardeh and Dahmardeh [32]. Banga *et al.* [33], Sharma and Jain [30] and Carson [12] reported that control of weeds manually, herbicides use and application of allelochemicals significantly improve the grain yield as compared to untreated plots. The higher weed density and accumulation of weed DM in weedy check might have reduced plant height, number of leaves and other growth attributes resulting in reduced fodder yield.

ANOVA **Table 2** showed that varying weed control strategies significantly affected the weed density, fresh weight of weeds and dry weight of weight of pearl millet whereas the sowing dates and interaction was not significant. Data presented in **Table 3** weed control methods significantly affect the weed infestation in pearl millet crop, but sowing date and their interactive affect was found is be non-significant. Maximum number of weeds (246.22 weeds $m^{-2}$) found in those plots which were under control treatment followed by weed control by $W_4$ (sorghum water extract 10%) then by $W_3$ (chemical method 73.22 weeds $m^{-2}$). The minimum weeds population (53.89 weeds $m^{-2}$) was found where weeds controlled by $W_2$ (cultural practices). Maximum biomass of weeds (742.33 $g{\cdot}m^{-2}$) followed by sorghum water extract 10% treatment which gave 288.22 $g{\cdot}m^{-2}$ fresh weight of weeds. In chemical method the maximum fresh weight of weeds was found to be 235.22 $g{\cdot}m^{-2}$ while minimum fresh weight of weeds (193.33 $g{\cdot}m^{-2}$) was recorded in cultural practices treatment. Maximum dry weight of weeds (148.20 $g{\cdot}m^{-2}$) was recorded in control treatment while minimum dry weight of weeds (38.33 $g{\cdot}m^{-2}$) was recorded where weeds were controlled by cultural practices. The chemical method of weed control gave the result (47.43 $g{\cdot}m^{-2}$ which was inferior then the dry weight of weed (58.12 $g{\cdot}m^{-2}$) recorded when plots were treated with 10% sorghum water extract.

Variation in weed density, weed fresh and dry weight by various weed control methods is due to the difference in efficiency in controlling weeds. Sharma and Gautam [34] and Tanveer *et al.* [35] found the maximum weed density in un-treated plots and better weed control was observed in different weed control treatments. These results are in analogy by the result of Balyan and Bhan [36], who reported that in pearl millet and maize carpet weed (*Trianthema portulacastrum* L.) can be considerably reduced by hand weeding and spray of atrazine @ 0.5 $kg{\cdot}ha^{-1}$. Inhibition of fresh weight of weed in this study, shows the effectiveness of different weed control treatments. These results are in accordance with findings of Joseph *et al.* [37], who reported that hand weeding as the herbicide application assured the weed free conditions and responsible for the considerable reduction in weed population and fresh weight of weeds. These results were also in accordance with the previous findings of Sandangi and barik [38], Armel *et al.* [39], and Muhammad and Hassan [40]. Induction in weed dry weight by various weed control methods is due to the difference in efficiency in controlling weeds and gave less weed biomass by different weed control methods. These findings were also supported by the work of Devender *et al.* [41], who reported

the weeding and other weed control methods significantly reduced the dry weight of all weeds.

## 4. Conclusion

In conclusion, the performance of pearl millet (*Pennisetum americanum* L.) sown on 30th June under two hand hoeings at 15 and 30 DAS for weed control was found to be the best in terms of the grain yield per ha compared with the other treatments. Sowing time and timely weed control practices assured less weed crop competition and increase productivity.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

## References

[1] MINFA (2011) Agriculture Statistic of Pakistan, Ministry of Food, Agriculture and Livestock. Government of Pakistan, Islamabad.

[2] Chughtai, S.R., Fateh, J., Munawwar, M.H., Aslam, M. and Malik, H.N. (2004) Alternative Use of Cereals-Methods and Feasibility: Pakistan Perspective. In: *CFC and ICRISAT*, Patancheru, 210-220.

[3] Hassan, M.U., Ahmad, A.U.H., Zamir, S.I., Haq, I., Khalid, F., Rasool, T. and Hussain, A. (2014) Growth, Yield and Quality Performance of Pearl Millet (*Pennisetum americanum* L.) Varieties under Faisalabad Conditions, Pakistan. *American Journal of Plant* Sciences, **5**, 2215-2223. https://doi.org/10.4236/ajps.2014.515235

[4] Bacci, L., Cantini, C., Pierini, F., Maracchi, G. and Reyniers, F.N. (1999) Effects of Sowing Date and Nitrogen Fertilization on Growth, Development and Yield of a Short-Day Cultivar of Millet (*Pennisetum glaucum* L.) in Mali. *European Journal of Agronomy*, **10**, 9-21. https://doi.org/10.1016/S1161-0301(98)00046-X

[5] Faridullah, A., Alam, M., Irshad, J., Khan, H. and Khan, K. (2010) Comparative Studies of Different Pearl Millet Varieties as Affected by Different Yield Components. *Electronic Journal of Environmental*, *Agricultural* and *Food Chemistry*, **9**, 1524-1253.

[6] Yusuf, M.J., Nab, I.G., Basit, A., Husnain, S.K. and Akhtar, L.H. (2012) Development of High Yielding Millet Variety "Sargodha Bajra-2011" Released for General Cultivation in Punjab Province of Pakistan. *Pakistan Journal* of *Agricultural* Sciences, **49**, 275-282.

[7] Jan, A., Khan, I., Ali, Amanullah, S. and Sohail, A. (2015) Sowing Dates and Sowing Methods Influenced on Growth Yield and Yield Components of Pearl Millet under Rainfed Conditions. *Journal of Environment and* Earth Science, **5**, 105-109.

[8] Khan, Z.H., Khalil, S.K., Nigar, S., Khalil, I., Haq, I., Ahmad, I., Ali, A. and Khan, M.Y. (2009) Phenology and Yield of Sweet Corn Landraces Influenced by Planting Dates. *Sarhad Journal of Agriculture*, **25**, 153-157.

[9] Soler, C.M.T., Maman, N., Zhang, X., Mason, S.C. and Hoogenboom, G. (2008) Determining Optimum Planting Dates for Pearl Millet for Two Contrasting Environments Using a Modelling Approach. *Journal* of *Agricultural Science*, **146**, 445-a459. https://doi.org/10.1017/S0021859607007617

[10] Farrell, T.C., Fox, K., Williams, R.L., Fukai, S. and Lewin, L.G. (2003) Avoiding Low

Temperature Damage in Australia's Millet Industry with Photoperiod Sensitive Cultivars. *Proceedings of the Australian Agronomy Conference*, Australian Society of Agronomy, Geelong, 2-6 February 2003.
http://www.regional.org.au/au/asa/2003/c/5/farrell.htm#TopOfPage

[11] Bahadur, S., Verma, S.K., Prasad, S.K., Madane, A.J., Maurya, S.P., Gaurav, Verma, V.K. and Sihag, S.K. (2015) Eco-Friendly Weed Management for Sustainable Crop Production—A Review. *Journal of Crop and Weed*, **11**, 181-189.

[12] Carson, A.G. (2008) Improving Weed Management in the Draft Animal-Based Production of Early Pearl Millet in the Gambia. *Tropical Pest Manage*, **33**, 359-363.
https://doi.org/10.1080/09670878709371183

[13] Knezevic, S.Z., Evans, S.P., Blankenship, E.E., Acker, R.C.V. and Lindquist, J.L. (2000) Critical Period for Weed Control: The Concept and Data Analysis. *Weed Science*, **50**, 773-786.
https://doi.org/10.1614/0043-1745(2002)050[0773:CPFWCT]2.0.CO;2

[14] Cheema, Z.A., Sadiq, H.M.I. and Khaliq, A. (2000) Efficacy of Sorgaab (Sorghum Water Extract) as a Natural Weed Inhibitor in Wheat. *International Journal of Agriculture and Biology*, **2**, 144-146.

[15] Cheema, Z.A. and Khaliq, A. (2000) Use of Sorghum Allelopathic Propertiesto Control Weeds in Irrigated Wheat in a Semi-Arid Region of Punjab. *Agriculture and Ecosystem Environment*, **79**, 105-112.
https://doi.org/10.1016/S0167-8809(99)00140-1

[16] Steel, R.G.D., Torrie, J.H. and Dickey, D.A. (1997) Principles and Procedures of Statistics. McGraw Hill Co. Inc., New York.

[17] Arif, M., Ihsanullah, S., Khan, S., Ghani, F. and Yousafzai, H.K. (2001) Response of Millet Varieties to Different Planting Methods. *Sarhad Journal of Agriculture*, **17**, 159-163.

[18] Mass, A.L., Hanna, W.W. and Mullinix, B.G. (2007) Planting Date and Row Spacing Affects Grain Yield and Height of Pearl Millet Tifgrain 102 in the Southeastern Coastal Plain of the United States. *Journal* of *SAT Agricultural Research*, **5**, 1-4.

[19] Siddig, A., Ali, M., Adam, K.I., Bahar, A.H. and Hassan, T.A. (2013) Effect of Sowing Date and Variety on Growth and Yield of Pearl Millet (*Pennisetumglaucum* L.) Grown on Two Soil Types under Rain-Fed Condition at Zalingei Area in Sudan. *ARPN Journal* of *Science and Technology*, **3**, 340-344.

[20] Dhage, V.J., Shete, B.T. and Patil, J.B. (2008) Effect of Integrated Weed Management on Growth Attributes of Pearl Millet-Pigeonpea Intercropping System. *Annual Review of Plant Physiology*, **22**, 183-185.

[21] Mathukia, R.K., Mathukia, P.R. and Polara, A.M. (2015) Intercropping and Weed Management in Pearl Millet (*Pennisetum glaucum*) under Rainfed Condition. *Agricultural Science Digest*, **35**, 138-141.
https://doi.org/10.5958/0976-0547.2015.00025.7

[22] Wailare, M.A. (2009) Responses of Pearl Millet (*Pennisetum glaucum* L.) to Varying Sowing Date and Variety at Bagauda, Kano State Nigeria. *Journal* of *Agriculture*, *Forestry and the Social Sciences*, **3**, 340-344.

[23] Shinde, S.H., Kolage, A.K. and Bhilare, R.L. (2001) Effect of Weed Control on Growth and Yield of Maize. *Journal of Maharashtra Agricultural Universities*, **26**, 212-213.

[24] Craine, J.M. and Dybzinski, R. (2013) Mechanisms of Plant Competition for Nutrients, Water and Light. *Functional Ecology*, **27**, 833-840.

[25] Asseng, S., Keulen, H.V. and Stol, W. (2000) Performance and Application of the

APSIM-N Wheat Model in the Netherlands. *European Journal of Agronomy*, **12**, 37-54. https://doi.org/10.1016/S1161-0301(99)00044-1

[26] Nalewaja, D.J., Matysiak, R. and Hanmker, P. (2007) Change in Efficacy of Glyphosate by Adjuvant. *Weed Technology*, **21**, 662-681.

[27] Eshraghi, N.M., Kamkar, B. and Soltani, A. (2011) The Effect of Sowing Date on Yield of Millet Varieties by Influencing Phonological Periods Duration. *Electronic Journal of Crop Production*, **4**, 169-188.

[28] Maqbool, M.M., Tanveer, A., Cheema, Z.A. and Ahmad, R. (2006) Growth and Yield of Maize (*Zea mays* L.) as Affected by Row Spacing and Weed Competitions Durations. *Pakistan Journal of Botany*, **38**, 12-27.

[29] Sahu, D.D., Solanki, R.M. and Chopada, M.C. (2010) Determination of Sowing Time for Rainfed Groundnut Using Heat Concept under South Saurashtra Agro Climatic Zone. Agrometeorological Services for Farmers AAU, Anand, 98-105.

[30] Sharma, O.L. and Jain, N.K. (2003) Integrated Weed Management in Pearl Millet (*Pennisetum glaucum* L.). *Indian Journal of Weed Science*, **35**, 34-35.

[31] Kumar, S., Singh, R., Shyan, R. and Singh, V.K. (2012) Weed Dynamics, Nutrients Removal and Yield of Wheat as Influenced by Weed Management Practices under Valley Conditions of Uttarakhand. *Indian Journal of Weed Science*, **44**, 110-114.

[32] Dahmardeh, M. and Dahmardeh, M. (2010) The Effect of Sowing Date and Some Growth Physiological Index on Grain Yield in Three Maize Hybrids in Southeastern Iran. *Asian Journal of Plant Sciences*, **9**, 432-436. https://doi.org/10.3923/ajps.2010.432.436

[33] Banga, R.S., Yadav, A., Malik, R.K., Pahwa, S.K. and Malik, R.S. (2000) Evaluation of Tank Mixture of Acetochlor and Atrazine or 2, 4-D Na against Weeds in Pearl Millet (*Pennisetum americanum* L.). *Indian Journal of Weed Science*, **32**, 194-198.

[34] Sharma, S.K. and Gautam, R.C. (2003) Effect of Dose and Method of Atrazine Application on No-Till Maize (*Zea mays* L.). *Indian Journal of Weed Science*, **35**, 131-133.

[35] Tanveer, A., Chaudhry, N.H., Ayub, M. and Ahmad, R. (2003) Effect of Cultural and Chemical Weed Control Methods on Weed Population and Yield of Cotton. *Pakistan Journal of Botany*, **35**, 161-166.

[36] Balyan, R.S. and Bhan, V.M. (1989) Competing Ability of Maize, Pearl Millet, Mung Bean and Cowpea with Carpet Weed under Different Weed Management Practices. *Crop Research*, **2**, 147-153.

[37] Joseph, P., Yenish, Doll, D.J. and Buhler, D.D. (1992) Effect of Tillage on Vertical Distribution and Viability of Weed Seed in Soil. *Weed Science*, **40**, 429-433.

[38] Sandangi, P.K. and Barik, K.C. (2007) Effect of Weed Management Practices on Nutrient Depletion by Weeds, Yield and Economics of Winter Irrigated Cotton (*Gossypium hirsutum* L.). *Indian Journal of Agronomy*, **52**, 172-175.

[39] Armel, G.R., Wilson, H.P., Richardson, R.J. and Hines, T.E. (2003) Mesotrione Combinations in No-Till Corn (*Zea mays*). *Weed Technology*, **17**, 111-116. https://doi.org/10.1614/0890-037X(2003)017[0111:MCINTC]2.0.CO;2

[40] Muhammad, N. and Hassan, W. (2003) Effects of Metolachlor (Dual Gold 960EC) on Weed Control and Yield in Different Crops. *Sarhad Journal of Agriculture*, **19**, 333-339.

[41] Devender, S., Tyagi, R.C., Agarwal, S.K. and Singh, D. (1998) Weed Control Methods in Spring Maize. *Haryana Agriculture University Journal of Research*, **28**, 21-25.