



Pearl millet (*Pennisetum glaucum*) growth and productivity under different sowing methods, mulching and foliar feeding of nutrients

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ABSTRACT

The present experiment was conducted during rainy (*kharif*) seasons of 2020 and 2021 at College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan to determine the effect of sowing technique, mulching, and NPK foliar fertilization on growth, yield, and yield attributes of pearl millet [*Pennisetum glaucum* (L.) R. Br.] in arid circumstances. Experiment consisted of 3 sowing methods, viz. direct seed sowing (45 cm × 15 cm); 2-week-old seedling (60 cm × 22.5 cm); and 4-week-old seedling (60 cm × 22.5 cm) transplanting; and 3 mulches, viz. no mulch; dust mulch; and straw mulch assigned to main-plot and 2 levels of NPK foliar fertilization [control and NPK @1% foliar spray at 35 and 50 DAS (days after sowing)] assigned to sub-plot. Results showed that transplanting 4-week-old seedlings led to significantly higher plant height (170.1 cm), dry-matter accumulation (133.6 g), total and effective tillers (3.41 and 3.14), ear head length (24 cm), ear head girth (2.28 cm), weight of ear head (31.5 g), grains/ear (1964), weight of grains/ear (18.9 g), comparable to 2-week seedling transplanting. The grain yield (2396 kg/ha) and straw yield (6640 kg/ha) were significantly superior with 4-week-old seedlings over 2-week seedling by 8.2, 5.4% on pooled basis. Straw mulch exhibited superior most for growth and yield parameters, followed by dust mulch. Additionally, NPK @1% foliar spray at 35 and 50 DAS resulted in significantly higher plant height (170.5 cm), dry-matter accumulation (131.6 g), ear head length (23.7 cm), ear head girth (2.27 cm), weight of ear head (31.1 g), grains/ear (1921), weight of grains/ear (18.5 g), compared to the control. The grain yield (2303 kg/ha) and straw yield (6548 kg/ha) were significantly superior with NPK @1% by 9.5% and 11% over control. In conclusion, the combination of transplanting 4-week-old seedlings, straw mulch and NPK @1% foliar spray offering a potential solution for enhancing agricultural productivity in the region.

Keywords: Foliar spray, Mulch, Seedlings, Sowing methods

Pearl millet [*Pennisetum glaucum* (L.) R.Br.] has been widely farmed, mostly in Africa and the Indian subcontinent. It is the most drought-tolerant cereal cultivated in arid and semi-arid regions of the world because of its short growing season (Bhagavatula *et al.* 2013). Pearl millet is also known as nutri-cereal these days due to its superior nutritional makeup. Millets have very high dietary carbohydrate content (60–70%), fibre content (10–12%) and low fat (1.5–5%), and

a significant mineral content (2–4%) (Annor *et al.* 2017). The 93.2% of the world's pearl millet is produced in Africa and India combined. After rice, wheat and sorghum pearl millet is India's fourth-most important grain crop, grown in arid and semi-arid regions and contributes 10.7% to total food grain production (Ramniwas *et al.* 2023). With 7.55 million hectares under cultivation and a yearly yield of 9.22 million tonnes, or 1374 kg/ha, India topped the world (GOI 2022). Because robust seedlings get chosen for a transplant, the probability of seedling mortality are lower with transplanting pearl millet compared with direct-seeding the crop. This assures strong crop stand establishment. In addition, compared to direct sowing, transplanting requires a lower seed rate for producing the ideal plant population (Traore *et al.* 2022). On the other hand, in certain parts of Rajasthan, seedlings are typically planted in the field after being raised in nurseries. Even yet, crops that are transplanted yield more than those that are seeded directly. Mulches are used in agriculture for numerous reasons, but in semi-arid and arid

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regions, they are particularly important for reducing erosion and conserving water (Kobayashi and Yato 2010, Dass and Bhattacharya 2017). For a long time, people have utilized natural mulches such as leaf, straw, decaying foliage, and compost; however, in the past 60 years, the introduction of synthetic materials has changed the processes and advantages of mulching (Sharma and Bharadwaj 2017). Additionally, mulch can successfully reduce weed growth, soil erosion, vaporized water loss, and the loss of nutrients (Chaudhary *et al.* 2003, Mozafari *et al.* 2020). If application to the soil has failed, foliar application of nutrients helps to meet the demand and increases fertilizer use efficiency. N, P and K fertilizers are more effectively applied through the foliage, which enhance crop growth (Rundla and Bairwa 2018, Dass *et al.* 2022). They have the most obvious and rapid effect on plant growth (Gurjar *et al.* 2022). Therefore, the goal of the current study was to determine how the sowing technique, mulching, and NPK foliar fertilization affect the growth, yield, and yield attributes of pearl millet grown in arid circumstances during the *kharif* season.

MATERIALS AND METHODS

The present experiment was conducted during rainy (*kharif*) seasons of 2020 and 2021 at College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan. The soil of study site was loamy sand and slightly alkaline in reaction (pH 8.1), poor in organic carbon (0.11%), low in available nitrogen (105.5 kg/ha) but medium in available phosphorus (15.1 kg/ha), potassium (173.1 kg/ha). Experiment was conducted in a split-plot design (SPD) with 3 replications. Experiment consisted of 3 sowing methods, viz. direct seed sowing (45 cm $\times$ 15 cm); 2-week old seedling transplanting (60 cm $\times$ 22.5 cm); and 4-week old seedling transplanting (60 cm $\times$ 22.5 cm); and 3 mulches, viz. no-mulch; dust mulch; and straw mulch in the main-plot, while 2 levels of NPK foliar fertilization (control and NPK @1% foliar spray at 35 and 50 days after sowing (DAS) were assigned to sub-plots. The crop (Super-99) was sown following the recommended spacing and package of practices. The chemical fertilizer urea and single super phosphate (SSP) were used to apply the recommended dose of fertilizers (60:40:0) in all treatments. The dust mulching was done after each heavy rainfall by Kassi. Mustard straw mulch @7.5 t/ha was spread in the ear-marked plots over the soil surface uniformly in between rows after plant emergence (15 DAS). The data on different growth, yield, and yield components, viz. plant height (cm), dry-matter accumulation (g/plant), total and effective tillers/plant, ear head length (cm), ear head girth (cm) (girth of ear head was measured at top, middle, and bottom of the ear head in centimeter by Vernier caliper and the mean value was recorded as a girth of ear head), ear head weight (g), grains/ear head, weight of grains/ear head as well as grain, straw and biological yield were recorded using standardized procedures. The data so recorded in both seasons' trials were subjected to ANOVA (analysis of variance) using the procedures described by Rana *et al.* (2014).

RESULTS AND DISCUSSION

Plant height and the amount of dry-matter accumulated at harvest were two measured development variables of pearl millet that were significantly affected by the seeding method (Table 1). On a pooled basis, transplanting 4-week-old seedlings produced plants that were substantially larger (170.1 cm) and with a DMA of 133.59 g/plant at harvest; however, the results were comparable to transplanting 2-week-old seedlings. Direct seed sowing techniques produced the significantly lowest growth attribute value. The main aspect of the shoot is strongly influenced by the length of the millet vegetative phase, which is the principal factor controlling crop duration variance. Compared to direct sowing, transplanted pearl millet produced higher plants and a greater accumulation of dry matter. Patil *et al.* (2018), found that the transplanting method recorded higher plant height than direct seeding. Among the mulches, straw mulch recorded a significant effect on growth parameters as compared to dust mulch at 30 DAS and no mulch practices. Hence, a significant improvement in plant height (172.9 cm) and dry-matter accumulation (136.2 g/plant) was recorded at harvest on pooled basis under straw mulch. The increased soil moisture and lower soil temperature under the straw mulch contributed to the plant's greater height by making water more readily available to the crop throughout the growing season and by maintaining a comfortable rhizosphere temperature. Verma *et al.* (2006) exhibited higher plant height of pearl millet under straw mulch as compared to no mulch. The significantly superior value of plant height (170.5 cm) and dry-matter accumulation (131.6 g/plant) at harvest was found on a pooled basis with foliar feeding over control. Better nutrition, which is essential for the plant's cell division and growth, may be the cause of the tallest plant (Rundla and Bairwa 2018, Dinesh *et al.* 2022a). The increased photosynthetic activity of the plant may be the reason for the improvement in dry-matter accumulation. Nitharwal *et al.* (2022) found that higher plant height and dry-matter accumulation of wheat were observed with the application of 3 foliar sprays @1% NPK (19:19:19) over all other treatments.

Among different methods of sowing, transplanting 4-week-old seedlings gave significantly superior no. of total tillers (3.41), effective tillers (3.14), ear head length (24 cm), ear head girth (2.28 cm), the weight of ear head (31.5 g), no. of grains/ear head (1964) and weight of grains/ear head (18.90 g) on a pooled basis compared to direct sowing, but this treatment was recorded statistically at par with 2-week-old seedlings transplanting (Table 1 and 2). The transplanted crop displayed better vegetative growth, which was seen in the taller plants and more tillers/plant. This might be owing to better water utilization and excellent soil-water-air relationship because due to the well-developed and established root system in transplanted crops, it extracted more moisture and nutrients from the soil (Dinesh *et al.* 2022b). According to Traore *et al.* (2022), transplanting significantly reduced the time to tillering, flowering, and

Table 1 Effect of sowing methods, mulching and NPK foliar fertilization on growth and yield attributes of pearl millet

Treatment	Plant height (cm)			DMA at harvest (g/plant)			Total tiller/plant			Effective tiller/plant		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
<i>Sowing method</i>												
Direct seed sowing (45 cm × 15 cm)	156.9	159.1	158.0	121.0	121.9	121.4	3.11	3.16	3.14	2.85	2.95	2.90
2-week-old seedlings transplanting (60 cm × 22.5 cm)	164.3	165.4	164.9	124.7	129.4	127.1	3.30	3.31	3.31	3.02	3.07	3.05
4-week-old seedlings transplanting (60 cm × 22.5 cm)	169.3	170.8	170.1	132.1	136.7	133.6	3.38	3.43	3.41	3.10	3.17	3.14
SEm ±	3.57	3.63	2.55	2.35	2.61	1.76	0.06	0.06	0.04	0.05	0.06	0.04
CD (P=0.05)	10.70	10.88	7.33	7.04	7.83	5.06	0.19	0.19	0.13	0.16	0.17	0.11
<i>Mulching</i>												
No mulch (Control)	157.1	159.2	158.1	119.1	122.8	120.7	3.19	3.19	3.19	2.90	2.97	2.94
Dust mulch at 30 DAS	161.3	162.6	161.9	124.0	126.9	125.2	3.21	3.26	3.24	2.95	3.03	2.99
Straw mulch @7.5 t/ha at sowing	172.1	173.6	172.9	134.7	138.3	136.2	3.40	3.45	3.42	3.12	3.20	3.16
SEm±	3.57	3.63	2.55	2.35	2.61	1.76	0.06	0.06	0.04	0.05	0.06	0.04
CD (P=0.05)	10.70	10.88	7.33	7.04	7.83	5.06	0.19	0.19	0.13	0.16	0.17	0.11
<i>NPK foliar fertilization</i>												
Control	157.6	158.6	158.1	121.5	125.2	123.1	3.24	3.27	3.25	2.96	3.04	3.00
NPK @1% foliar spray at 35 and 50 DAS	169.4	171.6	170.5	130.4	133.4	131.6	3.30	3.33	3.31	3.02	3.09	3.05
SEm±	1.92	1.84	1.33	1.60	1.52	1.10	0.04	0.03	0.03	0.03	0.03	0.02
CD (P=0.05)	5.70	5.48	3.82	4.76	4.52	3.17	NS	NS	NS	NS	NS	NS

DMA, Dry-matter accumulation; DAS, days after sowing.

maturity stages by 15, 27, and 11%, respectively. However the yield attributes were proved significantly maximum with an application of straw mulch over dust mulch and no mulch. Number of total tillers/plants (3.42) and effective tillers/plant (3.16), ear head length (24.4 cm), ear head girth (2.36 cm), weight of ear head (31.4 g), no. of grains/ear head (1966) and weight of grains/ear head (19 g) were recorded higher significantly with straw mulch on pooled basis as compared to no mulch and dust mulch. The increased number of tillers/plant, ear head length and girth, and ear head weight may be attributable to a better allocation of assimilates from the source toward reproductive regions while mulching. According to Bhatt *et al.* (2020), the use of greengram straw at the rate of 5 t/ha as mulch recorded significantly higher values of grain number of grains and cob length of maize than other organic. Kaur and Mahal (2017) observed that paddy straw mulch gave significantly a greater number of spikes than no mulch. A significant effect on all yield components was measured by foliar feeding of 1% NPK at 35 and 50 DAS over control. Yield components, viz. ear head length (3.72%), ear head girth (5.09%), the weight of ear head (5.72%), no. of grains/ear head (5.61%), and the weight of grains/ear head (12.2%)

increased due to foliar fertilization of @1% NPK at 35 and 50 DAS on pooled basis over control. However, no. of total and effective tiller was not influenced significantly due to foliar fertilization. A foliar spray of water-soluble complex fertilizer (19:19:19) produced a higher number of effective tillers and length of ear head of pearl millet (Patel *et al.* 2019). This could be a result of the fact that NPK are crucial nutrients needed to support meristematic and physiological processes. Present findings are in close agreement with the results of Rundla and Bairwa (2018).

Grain, straw and biological yields varied significantly with different sowing methods, mulching, and NPK foliar feeding (Fig. 1). Among different sowing methods transplanting 4-weeks-old seedlings gave significantly higher grain yield to the tune of 20.4 and 8% in 2020, 19.3 and 8.39% in 2021 and 19.9 and 8.2% on pooled data basis as compared to direct seed sowing and transplanting of 2-week-old seedlings, respectively. It might be due to patchy and unreliable rainfall which decreased the grain yield of pearl millet grown through direct seed sowing method. These results are in conformity with the findings of Shekhawat *et al.* (2015) who reported that pearl millet grown through the transplanted method produced higher grain yield as compared to the direct sowing

Table 2 Effect of sowing methods, mulching and NPK foliar fertilization on yield attributes of pearl millet

Treatment	Ear head length (cm)			Ear head girth (cm)			Weight of ear head (g)			Grains/ear head			Weight of grain/ear head (g)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
<i>Sowing method</i>															
Direct seed sowing (45 cm × 15 cm)	22.5	22.8	22.7	2.11	2.15	2.13	28.4	29.0	28.7	16.7	17.0	16.9	1733	1767	1750
2-week-old seedlings transplanting (60 cm × 22.5 cm)	23.0	23.2	23.1	2.21	2.25	2.23	30.3	30.7	30.5	18.2	18.3	18.3	1888	1905	1897
4-week-old seedlings transplanting (60 cm × 22.5 cm)	23.8	24.2	24.0	2.26	2.30	2.28	31.2	31.7	31.5	18.8	19.0	18.9	1956	1972	1964
SEm±	0.44	0.44	0.31	0.04	0.04	0.03	0.49	0.50	0.35	0.33	0.37	0.25	34	39	26
CD (P=0.05)	1.32	1.31	0.90	0.13	0.13	0.09	1.48	1.51	1.02	0.98	1.12	0.71	101	117	74
<i>Mulching</i>															
No mulch (Control)	22.5	22.8	22.6	2.12	2.15	2.13	29.2	29.6	29.4	17.3	17.4	17.3	1794	1807	1800
Dust mulch at 30 DAS	22.6	23.0	22.8	2.13	2.17	2.15	29.5	30.1	29.8	17.7	17.9	17.8	1835	1854	1844
Straw mulch @7.5 t/ha at sowing	24.2	24.5	24.4	2.35	2.38	2.36	31.3	31.6	31.4	18.8	19.1	18.9	1948	1984	1966
SEm±	0.44	0.44	0.31	0.04	0.04	0.03	0.49	0.50	0.35	0.33	0.37	0.25	34	39	26
CD (P=0.05)	1.32	1.31	0.90	0.13	0.13	0.09	1.48	1.51	1.02	0.98	1.12	0.71	101	117	74
<i>NPK foliar fertilization</i>															
Control	22.6	23.0	22.8	2.14	2.18	2.16	29.1	29.6	29.4	17.4	17.6	17.5	1811	1827	1819
NPK @1% foliar spray at 35 and 50 DAS	23.6	23.8	23.7	2.25	2.28	2.27	30.9	31.2	31.1	18.4	18.6	18.5	1907	1936	1921
SEm±	0.28	0.23	0.18	0.03	0.03	0.02	0.32	0.40	0.26	0.22	0.25	0.16	23	26	17
CD (P=0.05)	0.83	0.69	0.52	0.08	0.08	0.05	0.96	1.19	0.74	0.64	0.74	0.47	67	77	49
DAS, days after sowing.															

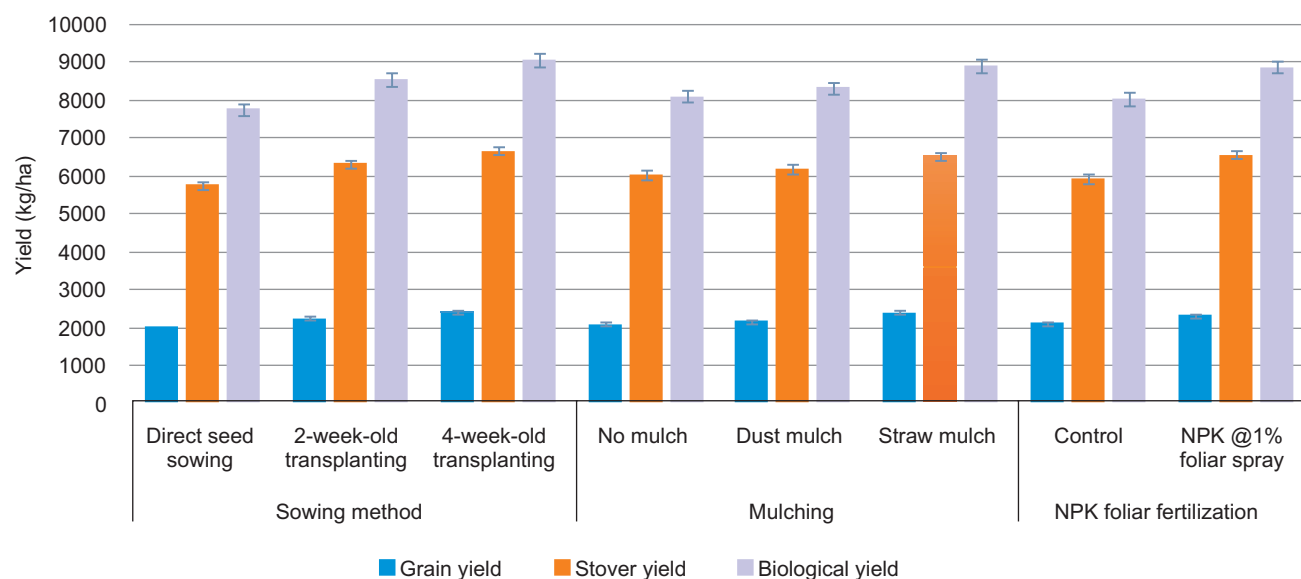


Fig. 1 Effect of sowing methods, mulching and NPK foliar spray on yields of pearl millet.

method. Straw (6640 kg/ha) and biological (9036 kg/ha) yield were also significantly superior with 4-week-old seedlings transplanting as compared to direct sowing and 2-week-old seedlings transplanting (Fig. 1). This might be due to increased morphological characters, viz. plant height, number of leaves/plants, number of tillers/plants and dry-matter production observed under transplanting of 4-week-old seedlings. Straw mulch recorded higher grain yield (2390 kg/ha), straw yield (6500 kg/ha) and biological yield (8891 kg/ha) as compared to no mulch and dust mulch on a pooled mean basis. The significant increase in grain and stover under straw mulch was largely a function of better plant growth physiological activities and consequent increase in yield attributes. This might be because that the straw mulch has more a pronounced effect on higher nutrient availability as well as more sustained soil moisture availability which creates an ideal environment for plant growth. Foliar spray of NPK @1% at 35 and 50 DAS statistically increased grain yield (9.46%), and straw yield (12%) on pooled basis over control. The positive effect of foliar spray of NPK on yield attributing characters of pearl millet seems to be due to the cumulative effect on the growth and vigour of plants. Amanullah *et al.* (2014) observed that foliar nutrition in maize with 2% each of NPK (1% each at 30 and 60 DAS) gave a significantly higher number of grains per ear along with higher grain yield over control. The increase in stover yield with foliar spray of NPK @1% could be partly attributed to its direct influence on dry-matter production of each vegetative part and indirectly through increased morphological parameters of growth. The profound influence of foliar spray of NPK on these components of crop growth led to the realization of higher biological yield.

Based on the 2-year field study, it can be concluded that planting technique, mulches and NPK foliar spray greatly increased the yield attributes and yield of pearl millet.

Above all, these strategies also provided farmers with a solution to the water scarcity in that desert location. In spite of increasing output by 19.9% over direct seed sowing, transplanting at 4 weeks of age resulted in a nursery that is also easily manageable in Rajasthan's fluctuating rainfall patterns. Evaporation is a significant issue during the *kharif* season and can be monitored in arid regions by mulching. The greatest yields of all yield parameters were appreciably achieved with straw mulch and NPK @1% at 35 and 50 DAS foliar spray, which also exceeded the other treatments.

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