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Shubha S
ICAR-Krishi Vigyana Kendra, Hittinahalli Farm, Vijayapur, UAS, Dharwad, Karnataka, India

Vivek S Devaranavadagi
ICAR-Krishi Vigyana Kendra, Hittinahalli Farm, Vijayapur, UAS, Dharwad, Karnataka, India

Shivalingappa Hotkar
ICAR-Krishi Vigyana Kendra, Hittinahalli Farm, Vijayapur, UAS, Dharwad, Karnataka, India

Corresponding Author:
Vivek S Devaranavadagi
ICAR-Krishi Vigyana Kendra, Hittinahalli Farm, Vijayapur, UAS, Dharwad, Karnataka, India

Effect of wide row spacing on growth and yield of pearl millet (*Pennisetum glaucum* L.) under rainfed conditions of northern Karnataka

Shubha S, Vivek S Devaranavadagi and Shivalingappa Hotkar

Abstract
A field demonstration was carried out at Hadagali village, Vijayapur district on Vertisols during *Kharif* 2017-18 and 2018-19 to study the effect of wide row spacing on pearl millet under rainfed conditions of Karnataka. The results indicated that wide row spacing conserved 44.82 and 63.80 per cent more soil moisture as compared to farmer's practice treatments for 2017-18 and 2018-19 respectively. Wide row spacing showed better performance for plant height, grain yield, fodder yield, gross return, net return and BC ratio over farmer's practice. Wide row spacing practice also exhibited higher grain yield of pearl millet 2368 kg ha^{-1} and 2402 kg ha^{-1} (for 2017-18 and 2018-19), fodder yield 4749 kg ha^{-1} and 4880 kg ha^{-1} (for 2017-18 and 2018-19), gross return Rs. 30256 ha^{-1} and Rs. 31645 ha^{-1} (for 2017-18 and 2018-19), net return Rs. 25250 ha^{-1} and Rs. 24578 ha^{-1} (for 2017-18 and 2018-19) and BC ratio 2.77 and 2.92 (for 2017-18 and 2018-19).

Keywords: Wide row spacing, pearl millet, soil moisture dynamics, Vijayapur, Karnataka

Introduction
Pearl millet [*Pennisetum glaucum* (L.)] is the fourth most significant cereal staple food crop in India, after rice, wheat and sorghum. It is commonly referred as Bajra and grown as a rainfed crop on marginal soils with minimum input management practices. Because it can grow under a variety of day lengths, temperature and moisture stress, the crop has a wide range of flexibility. The majority of Indian types are photosensitive, which makes it easier to grow the crop throughout the monsoon and *rabi* seasons. Low annual rainfall of 40-50 cm is required, as well as dry conditions. This crop thrives in light soils with low intrinsic fertility, excellent drainage and minimal salt.

In terms of protein, calories, vitamins and minerals, pearl millet grains are not only nutritionally equivalent, but also superior to main cereals (Parthasarathy Rao *et al.*, 2006) [5]. They are also high in dietary fibre, phytochemicals, micronutrients and neutraceuticals. Therefore they are often referred to as "nutricereals." During 2018-19, it covered 6.93 million hectares with an average production of 8.61 million tonnes and a productivity of 1243 kg ha^{-1} (Anon., 2020) [1]. Rajasthan, Maharashtra, Gujarat, Uttar Pradesh and Haryana are the primary pearl millet farming states, accounting for more than 90% of the country's pearl millet acreage. Abiotic stress such as drought, poor soil fertility, high soil pH and high temperature are the main reasons of low productivity. These variables reduce root uptake of applied nutrients and also prevent nutrients from being turned over at a pace that corresponds to crop nutritional requirements at different stages of growth.

Pearl millet is the most drought-tolerant warm-season cereal crop, primarily used as a staple food grain, feed, and fodder (Sathya *et al.*, 2013) [7]. It is also one of the most reliable cereal crops grown in rainfed dry and semi-arid tropics (Uzom *et al.*, 2010) [9]. Because of its efficient use of soil moisture and higher level of heat tolerance than sorghum and maize, it is suitable and efficient for semiarid climates (Shah *et al.*, 2012) [8].

Increased crop productivity is especially difficult in dry places, where farmers and scientists alike have a difficult task. While building ponds to conserve rainwater is a good idea, small farmers with less than 3.0 acres will find it difficult to do so. The Krishi Vigyan Kendra in Vijayapur, Karnataka, has created a strategy to help small farmers to overcome water constraints. Farmers are urged to plant their crops with a greater space between them as simple approach. Droughts are common in Vijayapur, which is located in northern Karnataka. The annual rainfall in this area is 594.4 mm, which is insufficient for most dryland crops.

Farmers generally use narrow row spacing when planting crops. Farmers follow a standard procedure, but they use their own spacings based on their preferences. As a result, the plant grows. There is a fierce competition for moisture among the plants. The moisture requirement will be higher, especially during the peak flowering and grain filling phases, but there will be less soil moisture leftover, affecting dry-land crop yield. Farmers in the Vijayapur district began planting their crops with wider row spacing of 120 cm (between rows) x 10 cm (between plants) and saw a 20-25 percent increase in pearl millet yield. Singh *et al.* (2007) [6] investigated the impact of moisture management practices on runoff and soil loss, as well as crop yield. When compared to traditional moisture management practices, improved management practices for soil and water conservation in vertisols reduced surface runoff by 24 to 27 percent and soil loss by 44 to 47 percent.

Methodology

A field demonstration was carried out during the rainy *(kharif*) season of 2017-18 and 2018-19 under northern dryzone of Karnataka at Hadagali village of Vijayapur district (situated at 16° 24' N latitude, 75° 55' E longitude and at an altitude of about 551 m above mean sea level). With the improved package of practice, assessment was carried out by taking 0.4 ha as a unit and covered a total area of 8.0 ha. The demonstration was carried out with 2 treatments (T_1=Farmers practice, T_2= wide row spacing) and 20 replications under randomized complete block design in the farmer's field. The land was brought to optimum tilth by ploughing twice with tractor drawn mould board plough. The soils of demonstration field for evaluating pearl millet crop was medium deep clay soil with pH 7.7, available organic carbon 0.37 per cent, available N, P and K were 269.1, 39.2 and 463.5 kg ha^{-1}, respectively.

Sowing of pearl millet was taken up in two consecutive years on 28th June 2018 and 25th June 2019, respectively. Seeds of pearl millet (hybrid) were sown in line using *pora* method (dropping the seeds in furrow behind the plough) of sowing and seed rate of pearl millet was 4.0 kg ha^{-1} in all two cropping systems. The recommended plant spacing of 120 X 10 cm for pearl millet was adopted. Weeds were controlled through one hoeing at 30 days after sowing and one manual weeding. Soil moisture status (using oven dry method) was recorded for every 30 days interval at 15 cm in both the years. The recommended rate of N (50 kg ha^{-1}) and P_2O_5 (25 kg ha^{-1}) was applied for pearl millet at sowing. The remaining cultivation practices were followed as per the package of practice of UAS, Dharwad. In both years, a pre-seasonal training and two trainings during the crop period were conducted to prepare the farmers on implementation of selected package of practices. Pearl millet was harvested on 22nd and 29th October 2018 and 2019, respectively. Five randomly selected plants from 20 sites in each treatment were harvested. Standard procedures were used to measure the yield attributes and yield parameters of pearl millet. Variables were analyzed and least significance difference (LSD) test was carried out for analyzed mean square errors using Web Based Agricultural Statistics software Package (WASP 2.0). Significance and non-significance difference between treatments was derived through procedure provides for a single LSD value (Gomez and Gomez, 1984) [2]. Correlation studies among the yield components of pearl millet was done using XLSTAT package.

Results and Discussion

Available soil moisture dynamics

The data on the influence of available soil moisture at 30, 60, 90 DAS and at harvest revealed that, wide row spacing technique, conserved 23.45, 45.67, 44.88 and 44.82 percent more soil moisture over farmers practice at tillering, flowering and grain filling stages of pearl millet for 2017-18 and 26.25, 59.48, 37.70 and 63.80 percent for 2018-19, respectively (Table.1). This is mainly due to the frequent deep inter cultivation in wider row spacing. Frequent deep inter cultivation helps to create dust mulch on the soil surface. This dust mulch acts as a barrier for the capillary rise of water which results in higher evaporation losses. These results are in agreement with Willey *et al*., (1977) [10] who revealed that in a moisture deficit situation as in *kharif*, wider rows recorded 93.2% higher yields in red soil and 15.8% in black soils. Wide row spacing treatment recorded higher soil moisture mainly due to greater infiltration by reduced runoff and subsequent arresting the evaporation of the infiltrated water and reduced weed growth apparently contributes to soil moisture gains.

Table 1: Soil moisture percentage (15 cm depth) at different stages for pearl millet

Treatments	Before sowing		30 DAS		60 DAS		90 DAS		At harvest	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Farmers practice (T_1)	16.2	21.0	16.2	24.0	16.2	11.6	17.6	18.3	11.6	10.5
Wide row spacing (T_2)	16.2	21.1	20.0	30.3	23.6	18.5	25.5	25.2	16.8	17.2

Growth parameters

The data suggests that there is increase and difference in plant height was observed over the entire crop growth period between check and demo due to maintenance of soil moisture status in the profile. The maximum plant height was observed in wide row spacing technique as compared with farmer's practice (Table.2). Wide row spacing significantly increased the plant height at harvest by 7.34 and 10.13 per cent over the farmer's practice treatment for 2017-18 and 2018-19 respectively. The increased growth in wide row spacing treatment was due to higher soil moisture conservation and better growth of plants. Shinggu and Gain (2002) reported that a narrow intra-row spacing of 10 cm produced taller finger millet plants than 20 cm intra-row spacing. Kamal *et al*., (2013) [4] who reported that the leaf area of pearl millet was higher at 90 cm row as compared to 50 cm spacing.

Table 2: Plant height (cm) of pearl millet under different stages of crop growth

Treatments	30 DAS		60 DAS		90 DAS		At harvest	
	2018	2019	2018	2019	2018	2019	2018	2019
Farmers practice (T_1)	45.0	42.3	90.2	87.5	121.2	116.0	121.6	120.4
Wide row spacing (T_2)	53.6	51.0	98.5	94.8	128.5	126.5	130.5	132.6
S.Em ±	2.868	2.946	3.041	2.461	2.385	3.532	2.016	3.436
CD (0.05)	8.651	8.854	9.150	7.423	7.465	10.627	6.056	10.328

Yield and economics

The difference in yield between the treatments was due to higher soil moisture availability at 15 cm depth of soil during the entire crop growth period. Among the different treatments the highest grain yield was observed in wide row spacing treatment 2368 kg ha^{-1} (2018) and 2402 kg ha^{-1} (2019) which is significantly higher than farmer's practice 2044 kg ha^{-1} (2018) and 1986 kg ha^{-1} (2019) respectively (Table.3). Wide row spacing increased the yield by 15.85 per cent (2018) and 20.94 per cent (2019) over the farmer's practice treatment.

Table 3: Yield and economics of pearl millet under different treatments

Treatments	Grain yield (Kg ha^{-1})		Fodder yield (Kg ha^{-1})		Gross return (Rs ha^{-1})		Net return (Rs ha^{-1})		B:C ratio	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Farmers practice (T_1)	2044	1986	4155	4286	26099	24555	20143	19255	1.95	2.14
Wide row spacing (T_2)	2368	2402	4749	4880	30256	31645	25250	24578	2.77	2.92
S.Em ±	108.3	138.6	197.5	197.4	1385.8	2363.2	1701.5	1773.5	0.274	0.259
CD (0.05)	325.6	417.3	594.7	595.1	4158.3	7092.6	5108.4	5324.6	0.829	0.788

The data indicates that among the different treatments higher gross returns of Rs. 30256 ha^{-1} (2018) and Rs. 31645 ha^{-1} (2019) with higher net returns of Rs. 25250 ha^{-1} (2018) and Rs. 24578 ha^{-1} (2019) was observed in wide row spacing which is significantly superior over farmer's practice. Gross returns, net returns and B:C ratio were higher in wide row spacing by 15.92, 25.35 and 42.05 per cent for 2018 and 28.87, 27.64 and 36.44 per cent for 2019 over farmer's practice respectively (Table.3). These results are in good agreement with Jimba and Adedeji (2003) [3] who reported that wider spacing had higher dry matter yield than the close spacing crops.

Conclusion

To increase the moisture availability to the agricultural crops in the individual farmer's field and to facilitate increased infiltration and percolation of rain water into the root profile, wide row spacing technique is most suitable for pearl millet. Performance of wide row spacing indicate that layout of farmer's fields with wide row spacing during rainy season (June-July) improves the soil moisture availability in the soil profile thus helps in higher moisture availability during entire growth period which produces greater pearl millet yields. Further layout of farmer's field with wide row spacing produces higher grain yield, fodder yield, gross returns, net returns and B:C ratio over farmers practice in pearl millet.

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