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YIELD AND ECONOMICS OF KODO MILLET (*PASPALUM SCROBICULATUM* L.) AS INFLUENCED BY ROW SPACINGS AND FERTILIZER LEVELS

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ABSTRACT

A field experiment was done on kodo millet during the *kharif* season of 2023 at Agronomy farm, College of Agriculture, Latur to study the response of kodo millet (*Paspalum scrobiculatum* L.) to row spacing and fertilizer levels. The experiment was laid out in randomized block design with two factors and replicated thrice. First factor consists of three rows spacing *viz*., S_1 - 22.5 cm × 10 cm, S_2 - 30 cm × 10 cm and S_3 - 45 cm × 10 cm, second factor consists of three fertilizer levels *viz*., F_1 - 75 % RDF, F_2 - 100 % RDF and F_3 -125 % RDF. The experimental results revealed that significantly highest values of yield parameters *viz*., number of ear head plant^{-1} (9.32), number of grains ear head^{-1} (268), ear head weight plant^{-1} (12.23 g) and ear head length (11.60 cm) were recorded with wider row spacing of 45 cm × 10 cm which was at par with 30 × 10 cm row spacing. Significantly highest values of grain yield (3515.74 kg ha^{-1}), biological yield (8550.22 kg ha^{-1}), gross monetary returns (106703 ha^{-1}) and net monetary returns (51590 ha^{-1}) values were recorded under closer row spacing of 22.5 × 10 cm, which was at par with 30 × 10 cm row spacing. However, among different levels of fertilizer, application of 125 % RDF recorded higher values of number of ear head plant^{-1} (9.33), number of grains ear head^{-1} (267), ear head weight plant^{-1} (12.12 g), ear head length (11.59 cm), grain yield (3464 kg ha^{-1}), biological yield (8416 kg ha^{-1}), gross monetary returns (105140 ha^{-1}) and net monetary returns (50324 ha^{-1}) as compared to 75 % RDF, which was found to be at par with application of 100 % RDF.
Keywords: Kodo millet, RDF, Fertilizer levels, Row spacings

Introduction

In recent years, millets have received increased attention and scrutiny because they are one of the best crop choices for climate-resilient agriculture. Moreover, millets are drought-tolerant, highly adaptable and resistant to diseases and pest and well-suited for dryland agricultural ecosystems. In the context of climate change, millets will be the "harbingers of an evergreen revolution". Kodo millet is a 'Nutri-Cereal' which comprises protein (8.3 g/100 g), fat (1.4 g/100 g), carbohydrate (65.9 g/100 g), ash (2.95 g/100 g), mineral (2.6 g/100 g) (Louhar *et al*., 2020). According to Bala *et al*., (2010), millets contain approximately 10 times more calcium and 2-10 times higher iron content compared to wheat or rice. It is grown on poor soils and it is widely distributed in the arid and semi-arid regions of India and African countries. Kodo millet cultivation is usually limited to Eastern Madhya Pradesh, parts of Tamil Nadu, Chhattisgarh and Karnataka. Madhya Pradesh and Tamil Nadu have the maximum share in production and promotion of kodo millet.

Kodo millet is being cultivated by Indian farmers without practicing proper date of sowing, seed rate, row spacing, nutrient management, weed management and other agronomic management practices. Among these, row spacing and nutrient management are important management practices which influence significant increase in growth and yield of kodo millet. Crop geometry is an important component to attain higher production through better utilization of moisture and nutrients from the below ground root spread and above ground plant canopy by harvesting maximum possible solar radiation and sequentially improves photosynthates formation. Kodo millet is grown in low-fertility soils in dryland regions with inadequate management practices, resulting in yields that are significantly below actual demand. Kodo millet responds favourably to fertilizers. Insufficient nutrition negatively impacts growth and yield, while excessive nutrition prolongs the vegetative phase, leading to an extended crop duration. Therefore, identifying the optimal fertilizer dosage is crucial for enhancing crop productivity. The proportionate use of three primary nutrients, namely, N, P and K as per the soil fertility status and balanced application of these three primary nutrients are recommended to obtain optimum productivity of crops. Considering above facts, the present investigation was carried out to study the response of kodo millet (*Paspalum scrobiculatum* L.) to row spacing and fertilizer levels.

Material and Methods

Experimental site and treatment details

A field experiment was conducted during the *kharif* season of 2023-24 at Agronomy farm, College of Agriculture, Latur (M.S.). The Latur district falls within the semi-arid zone of Maharashtra. The soil of the experimental site was clayey in texture, slightly alkaline, with a pH of 7.6, low available nitrogen (232.33 kg ha^{-1}), medium in available phosphorus (18.98 kg ha^{-1}) and high in available potassium (454.48 kg ha^{-1}). The experiment was laid out in Factorial Randomized Block Design (FRBD) with two factors and replicated thrice. First factor consists of three rows spacing *viz*., S_1 - 22.5 cm × 10 cm, S_2 - 30 cm × 10 cm and S_3 - 45 cm × 10 cm, second factor consists of three fertilizer levels *viz*., F_1 - 75 % RDF, F_2 -100 % RDF and F_3 - 125 % RDF. Each experimental unit was 5.4 m × 4.5 m in size. The net plot size varied as per the treatments. Kodo millet cultivar TNAU-86 was used in the experiment. Sowing was done on 07 July, 2023 by dibbling. Seed rate used for sowing was depended upon different row spacing. The recommended fertilizer dose of 40:20:20 NPK kg ha^{-1} was applied. Half the dose of nitrogen and entire dose of phosphorus and potassium in the form of urea, single super phosphate (SSP) and muriate of potash (MOP) respectively were applied as per the treatments at the time of sowing. Remaining 50 % of nitrogen was applied at 30 DAS. The recommended cultural practices and plant protection measures were undertaken. The statistical technique for the analysis of variance was employed to analyse the recorded data (Panse and Sukhatme, 1967).

Methodology

1. Number of ear heads plant^{-1}

The number of ear heads in the five composite plants were individually counted and averaged.

2. Number of grains ear head^{-1}

The five sampled plants selected at random for recording observations, were used for recording the number of grains plant^{-1}.

3. Ear head length (cm)

Ear head length was measured from base to the tip of ear head and it was expressed in cm.

4. Ear head weight (g)

The ear head weight was worked out by taking the oven dry weight of ear head.

5. Weight of ear heads plant^{-1} (g)

The weight of harvested ear heads from five composite plants was weighed individually and averaged and expressed in g.

6. Test weight (g)

Grain sample were drawn from the net plot yield of each treatment and from these, 1000 grains were counted and weighed in g.

7. Grain yield (kg ha^{-1})

The grain yield per net plot was recorded and computed on hectare basis after multiplied with the hector factor, which is expressed in kg ha^{-1}.

8. Biological yield (kg ha^{-1})

The biological yield refers to the total biomass produced by a crop, which includes both the grain and straw yield and expressed in kg ha^{-1}.

9. Gross monetary returns (ha^{-1})

The gross monetary returns obtained under different treatments in the present study, were calculated based on the prevailing market prices of produce of kodo millet during the experimental year and expressed as ha^{-1}.

10. Net monetary returns (ha^{-1})

The net monetary returns of each treatment were calculated by deducting the cost of cultivation of respective treatments from gross monetary returns for the corresponding treatments and expressed as ha^{-1}.

11. Benefit Cost Ratio

Benefit cost ratio was worked out for each treatment by using the following formula.

$$\text{B : C ratio} = \frac{\text{Gross returns (Rs. ha}^{-1})}{\text{Cost of cultivation (Rs. ha}^{-1})}$$

Statistical analysis and interpretation of data

Data obtained on various variables were analysed by Fisher's method of analysis of variance and interpretation of the data has been given by Panse and Sukhatme (1967). The level of significance used in 'F' test was at P=0.05. Critical difference values were calculated for comparison of treatment means whenever "F" was significant.

Result and Discussions

Yield attributes

Yield attributing characters of kodo millet *viz*., number of ear heads plant^{-1}, number of grains ear head^{-1}, ear head length (cm), ear head weight plant^{-1} (g) and test weight (g) were influenced by row spacing and fertilizer levels, are presented in Table 1.

Effect of row spacing

Among the various row spacings, wider row spacing of 45 cm × 10 cm resulted in higher number of ear heads plant^{-1} (9.32), number of grains ear head^{-1} (268), ear head length (11.6 cm) and ear head weight plant^{-1} (12.23 g) at harvest, which were at par with row spacing of 30 × 10 cm and found significantly superior over row spacing of 22.5 × 10 cm. Wider row spacing in kodo millet enhanced ear head numbers by providing better light interception, reducing competition for resources like nutrition and moisture. Consequently, the favourable conditions created by wider spacing resulted in more vigorous tillering, which generally increased number of ear heads plant^{-1}, promoted the growth of longer ear heads, ultimately results in a greater number of grains ear head^{-1} and all of which contributed to larger and heavier ear heads. Test weight of kodo millet did not differ significantly due to row spacings. The results were found to correlate with the findings of Prakash (2014), Sharma *et al*., (2020) and Triveni *et al*., (2023)

Effect of fertilizer levels

Among different levels of fertilizer, the highest values of number of ear head plant^{-1} (9.33), number of grains ear head^{-1} (267), ear head length (11.59 cm) and ear head weight plant^{-1} (12.12 g) were recoded with application of 125 % RDF, which was at par with 100 % RDF and found significantly superior over 75 % RDF. This increased fertilizer levels positively influenced the development of tillers, which leads to higher number of productive tillers and consequently, a greater number of ear heads plant^{-1}. Increased ear head length due to higher fertilizer levels may result from enhanced nitrogen and phosphorus availability, leading to greater accumulation of photosynthetic assimilates which generally increased grain filling, which in turn resulted in higher number of grains ear head^{-1}. Higher carbohydrate availability led to greater biomass accumulation and heavier ear heads. The results were found to correlate with the findings Sharma *et al*., (2020) and Triveni *et al.,* (2023).

Yield

Data in Table 2 revealed that grain and biological yield of kodo millet was affected significantly due to difference fertilizer level of and row spacings.

Effect of row spacing

Among different row spacings, the narrow row spacing of 22.5 × 10 cm recorded highest grain (3516 kg ha^{-1}) and biological (8550 kg ha^{-1}) yield, which were found to be at par with row spacing of 30 × 10 cm and found significantly superior over wider row spacing of 45 × 10 cm. The harvest index of kodo millet which was found to be non-significant with respect to row spacing. Narrow row spacing in kodo millet improved yield by increasing the number of plants per unit area. The denser planting arrangement led to higher total grain yield due to more efficient use of light and nutrients. Thus, higher plant density was the primary reason for higher yield, which was observed with narrower row spacing. Individual plants performed better in wider spacing of 45 × 10 cm. The results are in accordance with the findings of Hebbal and Ramachandrappa (2017) and Sharma *et al*. (2020).

Effect of fertilizer levels

The application of 125 % RDF recorded highest grain (3464 kg ha^{-1}) and biological (8416 kg ha^{-1}) yield, which was at par with 100 % RDF and found significantly superior over application of 75 % RDF. The increase in grain yields with increased NPK application is primarily attributed to improved nutrient availability and uptake, which subsequently enhanced metabolic efficiency and overall plant productivity. The interaction effect of nitrogen, phosphorus and potassium, which enhanced yield attributing parameters resulted in higher yield. The results were found to correlate with the findings of Vidya and Raundal (2018), Anitha *et al*. (2020), Kiran (2020), Sharma *et al*. (2020) and Soutade and Raundal (2022). The harvest index (%) of kodo millet which was found to be non-significant with respect to fertilizer levels.

Economics

The gross monetary returns (ha^{-1}), net monetary returns (ha^{-1}) and B:C ratio of kodo millet were affected significantly due to different row spacings and fertilizer levels, are presented in Table 2.

Effect of row spacing

Among different row spacings, the highest gross monetary returns (1,06,703 ha^{-1}), net monetary returns (51,590 ha^{-1}) and benefit cost ratio (1.93) of kodo millet were recorded with closer row spacing of 22.5 × 10 cm, which were comparable with row spacing of 30 × 10 cm and significantly over wider row spacing of 45 × 10 cm. The increased net returns with this narrower row spacing were primarily due to the higher grain yield. The higher plant population in the closer row spacing 22.5 × 10 cm resulted in a greater grain yield compared to the wider 45 × 10 cm row spacing. The results were found to correlate with the findings of Roy *et al.* (2001), Hebbal *et al.* (2018), Mane (2019) and Govinakoppa (2021).

Effect of fertilizer level

Highest gross monetary returns (1,05,140 ha^{-1}), net monetary returns (50,324 ha^{-1}) and benefit cost ratio (1.91) were achieved with application of higher fertilizer dose of 125 % RDF, which was at par with application of 100 % RDF and found significantly superior over application of 75 % RDF. The increased net monetary returns with higher fertilizer level were primarily due to the higher grain yield. The results were found to be consistent with the findings of Patil *et al.* (2015), Hebbal *et al.* (2018), Mane (2019), Kiran (2020), Govinakoppa *et al.* (2021) and Sadhana *et al.* (2021).

Interaction Effect

The interaction effect of row spacing and fertilizer levels on the yield attributes, yield and economics were found to be statistically non-significant.

Conclusion

From above results it can be concluded that among different row spacings, yield attributing characters of kodo millet were significantly higher with wider row spacing of 45 × 10 cm. However narrow row spacing of 22.5 × 10 cm resulted in higher grain and biological yield of kodo millet and it was followed by 30 × 10 cm row spacing. Significantly higher gross monetary returns, net monetary returns and benefit cost ratio were recorded with closer row spacing of 22.5 × 10 cm, which was followed by 30 × 10 cm row spacing. With respect to the applied fertilizer levels, application of 125 % RDF recorded higher yield attributes, grain yield, biological yield, gross monetary returns, net monetary returns and benefit cost ratio which was followed by 100 % RDF.

Table 1: Number of ear head $plant^{-1}$, number of grains ear $head^{-1}$, Ear head weight (g $plant^{-1}$), Ear head length (cm) and Test weight (g) of kodo millet as influenced by different treatments.

Treatment	No. of ear head $plant^{-1}$	No. of grains ear $head^{-1}$	Ear head weight (g $plant^{-1}$)	Ear head length (cm)	Test weight (g)
Row Spacing (S)					
S_1: 22.5 cm × 10 cm	7.86	238	10.58	10.41	6.55
S_2: 30 cm × 10 cm	8.97	247	11.46	10.85	6.66
S_3: 45 cm × 10 cm	9.32	268	12.23	11.60	6.99
S.E. (m)±	0.21	7.87	0.33	0.27	0.16
C.D. at 5%	0.64	23.60	0.99	0.80	NS
Fertilizer levels (F)					
F_1: 75% RDF	7.94	235	10.77	10.38	6.40
F_2: 100% RDF	8.88	252	11.38	10.89	6.82
F_3: 125% RDF	9.33	267	12.12	11.59	6.98
S.E. (m)±	0.21	7.87	0.33	0.27	0.16
C.D. at 5%	0.64	23.60	0.99	0.80	NS
Interaction (S × F)					
S.E. (m)±	0.37	13.64	0.57	0.46	0.28
C.D. at 5%	NS	NS	NS	NS	NS

Table 2: Grain yield (kg ha^{-1}), Biological yield (kg ha^{-1}), harvest index, gross monetary returns (ha^{-1}), net monetary returns (ha^{-1}) and B:C ratio of kodo millet as influenced by different treatments.

Treatment	Grain yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index	Gross monetary returns (ha^{-1})	Net monetary returns (ha^{-1})	B:C ratio
Row Spacing (S)						
S_1: 22.5 cm × 10 cm	3516	8550	41.22	106703	51590	1.93
S_2: 30 cm × 10 cm	3295	8053	40.78	99989	46847	1.88
S_3: 45 cm × 10 cm	2846	7048	39.00	86377	35040	1.68
S.E. (m)±	91	193	1.06	2771	1207	0.05
C.D. at 5%	274	579	NS	8308	3621	0.15
Fertilizer levels (F)						
F_1: 75% RDF	2912	7251	40.00	88371	37005	1.72
F_2: 100% RDF	3280	7984	39.89	99559	46147	1.86
F_3: 125% RDF	3464	8416	41.11	105140	50324	1.91
S.E. (m)±	91	193	1.06	2771	1207	0.05
C.D. at 5%	274	579	NS	8308	3621	0.15
Interaction (S × F)						
S.E. (m)±	158	334	1.84	4800	2092	0.09
C.D. at 5%	NS	NS	NS	NS	NS	NS

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