J. Farm Sci., 35(4): (430-433) 2022

RESEARCH PAPER

Effect of date of sowing, row spacing and fertilizer levels on yield and economics of Kodo millet (*Paspalum scrobiculatum* L.)

A. JALAJAKSHI[1], S.VISHWANATHA[1], B. G. KOPPALKAR[1], M. Y. AJAYAKUMAR[1] AND N. L. RAJESH[2]

[1]Department of Agronomy, [2]Department of Soil Science and Agricultural Chemistry, College of Agriculture
University of Agricultural Sciences, Raichur - 584 104, Karnataka, India
E-mail jalajamanu999@gmail.com

(Received: October, 2022 ; Accepted: November, 2022)

Abstract: A field experiment was conducted at The College of Agriculture farm, Raichur on medium black soil during *kharif,* 2021 to study the effect of date of sowing, row spacing and fertilizer levels on yield and economics of Kodo millet (*Paspalum scrobiculatum* L.) The results revealed that, early sowing during first fortnight of July recorded higher ear head weight (9.69 g), ear head length (6.41 cm), test weight (5.93 g), grain yield (2147 kg ha^{-1}), straw yield (3701 kg ha^{-1}), gross returns (₹ 87732 ha^{-1}), net returns (₹ 57008 ha^{-1}) and B:C (2.85). However, sowing during second fortnight of July was found to be on par with first fortnight of July. Among fertilizer levels and row spacing, application of 125 % RDF with 45 cm row spacing recorded significantly higher ear head weight (8.78 g), ear head length (6.18 cm) and test weight (5.52 g). Whereas, treatment receiving 125 % RDF with 30 cm row spacing recorded significantly higher grain yield (2164 kg ha^{-1}), straw yield (3772 kg ha^{-1}), gross returns (₹ 88443 ha^{-1}), net returns (₹ 56857 ha^{-1}) and B:C (2.81).

Key words: Dates of sowing, Economics, Fertilizer levels, Kodo millet, Row spacing, Yield. Yield attributes

Introduction

Minor millets are considered as small millets having remarkable ability to survive under extreme drought conditions. Minor millets have gained their attention owing to their inherent capacity of early maturity, higher yield due to C_4 plant type, capacity to yield even in poor soil under low rainfall and poor management conditions hence they are popularly known as "climate resilient" crops in Indian agriculture. Minor millets are also considered as 'miracle crop' because these have multifaceted use. Kodo millet (*Paspalum scrobiculatum* L.) is one among minor millet crops which is self-pollinating belongs to the family poaceae. In India, its distribution is primarily concentrated in Deccan region and its cultivation is generally confined to Gujarat, Karnataka, Madya Pradesh, Maharashtra and parts of Tamil Nadu and also spread to the foot hills of Himalayas. Madhya Pradesh and Tamil Nadu have the maximum share in production and promotion of Kodo millet. The grains contain 8.3 per cent protein, 1.4 per cent fat, 65.6 per cent carbohydrates and 2.9 per cent ash. It is rich in dietary fibre, minerals and antioxidants than any other millet. It is having high amount of lecithin, it can be recommended for strengthening of nervous system. It is rich in vitamin B, especially niacin, B_6 and folic acid as well as minerals like calcium, iron, potassium, magnesium and zinc. It can be recommended for gluten intolerant people because of absence of gluten. The grain is recommended as substitute for rice to patients suffering from diabetes disease.

Kodo millet is being cultivated by farmers in north eastern dry zone of Karnataka without practicing proper date of sowing, seed rate, row spacing, nutrient management, weed management and other agronomic management practices. Among these date of sowing, row spacing and nutrient management are important agronomic practices and following of proper agronomic practices will boost yield of Kodo millet.

Material and methods

A field experiment was conducted during *kharif*, 2021 at Agricultural college farm, Raichur, Karnataka, which comes under North Eastern Dry Zone (Zone II) of Karnataka. The experiment was laid out in split-plot design with 20 treatment combinations and replicated thrice. The treatments consist of five dates of sowing as main plots (D_1: first fortnight of July, D_2: second fortnight of July, D_3: first fortnight of August, D_4: second fortnight of August and D_5: first fortnight of September) and four fertilizer levels with row spacing as subplots (F_1S_1: 100 % RDF with 30 cm row spacing, F_2S_1: 125 % RDF with 30 cm row spacing, F_1S_2: 100 % RDF with 45 cm row spacing and F_2S_2: 125 % RDF with 45 cm row spacing). Recommended dose of fertilizer was 30:15:15 kg NPK ha^{-1}. Half the dose of nitrogen and entire dose of phosphorous and potassium in the form of urea, diammonium phosphate (DAP) 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. Sowing was done on five different dates (D_1: 13th July, D_2: 27th July, D_3: 9th August, D_4: 23rd August and 6th September). The variety HRK-1 was used for experimentation.

Results and discussion

Effect of dates of sowing

The grain and straw yield of Kodo millet was significantly influenced due to different dates of sowing (Table 1). Sowing during first fortnight of July recorded significantly higher grain and straw yield (2147 and 3701 kg ha^{-1}, respectively) followed by crop sown on second fortnight of July (2046 and 3583 kg ha^{-1}, respectively). Late sowing during first fortnight of September recorded significantly lower grain and straw yield (1428 and 2819 kg ha^{-1}, respectively). Significantly higher yield in first fortnight of July is mainly due to the increase in yield attributing characters like ear head length (6.41 cm), ear head weight (9.69 g) and test weight (5.93 g) followed by second fortnight of July (6.18 cm, 9.34 g and 5.72 g, respectively). The reason could be that early sown crop was exposed to favourable weather parameters such as temperature, sunshine hours, relative humidity, had high light interception, low moisture stress, suitable and longer environmental conditions for vegetative growth that helped to express full potential which resulted in the active photosynthesis and more translocation of assimilates in the reproductive parts. Similar findings were reported by Amanullah *et al*. (2015), Maurya *et al*. (2016), Gavit *et al*. (2017) and Saikishore *et al*. (2020).

The data presented in Table 2 revealed that higher gross returns, net returns and B:C ratio were recorded in crop sown during first fortnight of July (₹ 87732 ha^{-1}, ₹ 57008 ha^{-1} and 2.85, respectively) followed by second fortnight of July (₹ 83624 ha^{-1}, ₹ 52901 ha^{-1} and 2.72, respectively). Late sowing during first fortnight of September recorded significantly lowest gross returns, net returns and B:C ratio (₹ 58533 ha^{-1}, ₹ 26969 ha^{-1} and 1.85, respectively). The acceptance of any new practices by the farmers is ultimately depends on the economics involved in the crop production. Improved grain and straw production from sowing during the first fortnight of July over the other sowing dates was the primary factor in the increased gross returns, net returns, and benefit cost ratio. Upadhyay *et al*. (2001), Dapake *et al*. (2016) and Mubeena *et al*. (2019) found similar outcomes.

Effect of fertilizer levels with row spacing

Yield attributes were Significantly influenced due to fertilizer levels and row spacing (Table 1). Application of 125 % RDF with row spacing of 45 cm recorded higher ear head length (6.18 cm), ear head weight (8.78 g) and test weight (5.52 g) followed by the treatment receiving 100 % RDF with 45 cm row spacing (5.86 cm, 8.32 g and 5.25 g, respectively). Lowest values were obtained in treatment receiving 100 % RDF with row spacing of 30 cm (5.19 cm, 7.39 g and 4.69 g, respectively). Improved yield parameters *viz*., ear head weight, ear head length and test weight with greater fertilizer levels may be attributed to better growth attributes like tillers, leaf area and leaf area index of the crop, effective dry matter partitioning and enhanced translocation to the sink leading to the formation of more number of filled grains and large sized grains in ear head which ultimately resulted in higher ear head weight, ear head length and test weight. This was in conformity with the findings of

Table 1. Effect of dates of sowing, row spacing and fertilizer levels on yield attributing characters and yield of kodo millet

Treatment	Ear head weight (g $plant^{-1}$)	Ear head length (cm $plant^{-1}$)	Test weight (1000 grains)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
		Date of sowing (D)			
D_1	9.69 a	6.41 a	5.93 a	2147 a	3701 a
D_2	9.34 a	6.18 a	5.72 a	2046 a	3583 a
D_3	8.71 b	5.69 b	5.06 b	1832 b	3360 b
D_4	7.02 c	5.29 c	4.59 c	1625 c	3018 c
D_5	5.53 d	4.89 d	4.15 d	1428 d	2819 d
S. Em. ±	0.12	0.11	0.13	58	56
		Fertilizer levels (F) with row spacing (S)			
F_1S_1	7.39 d	5.19 d	4.69 d	1903 b	3533 b
F_2S_1	7.73 c	5.54 c	4.90 c	2164 a	3772 a
F_1S_2	8.32 b	5.86 b	5.25 b	1490 d	2849 d
F_2S_2	8.78 a	6.18 a	5.52 a	1706 c	3031 c
S. Em. ±	0.11	0.10	0.07	65	36
		Interaction (D X FS)			
$D_1F_1S_1$	8.99 def	5.97 bcde	5.32 def	2351 ab	3886 a
$D_1F_2S_1$	9.13 cdef	6.13 bcd	5.64 cd	2586 a	4129 a
$D_1F_1S_2$	10.00 ab	6.50 abc	6.16 ab	1701 def	3327 cd
$D_1F_2S_2$	10.62 a	7.03 a	6.62 a	1950 bcd	3461 bc
$D_2F_1S_1$	8.84 ef	5.75 cdef	5.18 defg	2199 abc	3908 a
$D_2F_2S_1$	9.08 def	6.00 bcde	5.39 de	2440 a	4084 a
$D_2F_1S_2$	9.55 bcde	6.32 abc	6.00 bc	1648 def	3076 def
$D_2F_2S_2$	9.88 abc	6.67 ab	6.31 ab	1896 bcde	3266 cde
$D_3F_1S_1$	7.84 gh	5.27 efgh	4.87 fgh	1880 bcde	3633 b
$D_3F_2S_1$	8.37 fg	5.54 defg	5.00 efg	2246 ab	3890 a
$D_3F_1S_2$	8.99 def	5.83 cdef	5.12 efg	1445 ef	2877 fgh
$D_3F_2S_2$	9.66 bcd	6.12 bcd	5.26 defg	1759 cdef	3041 ef
$D_4F_1S_1$	6.40 jk	4.60 hi	4.20 ij	1626 def	3257 cde
$D_4F_2S_1$	6.66 ij	5.24 efgh	4.42 hi	1939 bcde	3482 bc
$D_4F_1S_2$	7.31 hi	5.53 defg	4.77 gh	1353 f	2597 ij
$D_4F_2S_2$	7.69 gh	5.80 cdef	4.95 efg	1583 def	2737 ghi
$D_5F_1S_1$	4.89 m	4.37 i	3.90 j	1459 def	2980 fg
$D_5F_2S_1$	5.41 lm	4.79 ghi	4.05 ij	1610 def	3276 cde
$D_5F_1S_2$	5.78 kl	5.10 fgh	4.19 ij	1301 f	2370 j

Table 2. Effect of dates of sowing, row spacing and fertilizer levels on economics of kodo millet

Treatment	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:Cratio
	Dates of sowing (D)		
D_1	87732 a	57008 a	2.85 a
D_2	83624 a	52901 a	2.72 a
D_3	74975 b	43162 b	2.35 b
D_4	66519 c	34706 c	2.09 c
D_5	58533 d	26969 d	1.85 d
S. Em. ±	2331	2331	0.07
	Fertilizer levels with row spacing (FS)		
F_1S_1	77892 b	46717 b	2.51 b
F_2S_1	88443 a	56857 a	2.81 a
F_1S_2	61012 d	29943 d	1.97 d
F_2S_2	69760 c	38280 c	2.22 c
S. Em. ±	2609	2609	0.08
	Interaction (D X FS)		
$D_1F_1S_1$	95996 ab	65425.17 ab	3.14 ab
$D_1F_2S_1$	105495 a	74513.23 a	3.41 a
$D_1F_1S_2$	69714 defg	39249.00 def	2.29 defg
$D_1F_2S_2$	79721 bcd	48845.17 bcd	2.58 bcde
$D_2F_1S_1$	89927 abc	59356.33 abc	2.94 abc
$D_2F_2S_1$	99622 a	68640.00 a	3.22 a
$D_2F_1S_2$	67475 defg	37010.33 def	2.21 efg
$D_2F_2S_2$	77473 bcdef	46596.83 cde	2.51 cdef
$D_3F_1S_1$	77003 bcdef	45342.33 cde	2.43 cdef
$D_3F_2S_1$	91772 ab	59699.67 abc	2.86 abcd
$D_3F_1S_2$	59238 fg	27683.33 ef	1.88 fg
$D_3F_2S_2$	71888 cdefg	39922.33 def	2.25 defg
$D_4F_1S_1$	66668 defg	35007.33 def	2.11 efg
$D_4F_2S_1$	79288 bcde	47215.83 bcde	2.47 cdef
$D_4F_1S_2$	55418 g	23863.33 f	1.76 g
$D_4F_2S_2$	64702 defg	32735.67 def	2.02 efg
$D_5F_1S_1$	59863 efg	28452.33 ef	1.91 fg
$D_5F_2S_1$	66038 defg	34216.00 def	2.08 efg
$D_5F_1S_2$	53212 g	21906.67 f	1.70 g

Basavarajappa *et al.* (2002), Mubeena *et al.* (2020) and Siddiqui *et al.* (2020). Plants at wider row spacing exploited maximum natural resources efficiently, besides responding to externally applied inputs and expresses its maximum potential compared to plants at closer spacing where competition would be high. Therefore, wider spacing improves the partitioning of photosynthates to the reproductive parts. Ram *et al.* (2014) and Kumar *et al.* (2019) also reported similarly.

The grain and straw yield of Kodo millet was significantly influenced due to the application of RDF and row spacing (Table 1). Application of 125 % RDF with 30 cm row spacing recorded significantly higher grain and straw yield (2164 and 3772 kg ha^{-1}, respectively) followed by 100 % RDF with 30 cm row spacing (1903 and 3533 kg ha^{-1}). Lowest grain and straw yield were recorded in treatment receiving 100 % RDF with 45 cm row spacing (1490 and 2849 kg ha^{-1}). The high favourable effects of N, P and K such as high chlorophyll synthesis and dehydrogenase activity, also higher source to sink relationship on yield contributing characters could be used as an explanation for the increase in grain production with increased nutrient availability and also high rate of nutrient application improved the growth and yield components by enabling the land to trap higher quantity of radiant energy to convert it into chemical energy. These results support the conclusions of Kaushik and Mahendra (1983), Nigade *et al.* (2006), Chouhan *et al.* (2015), Jyothi *et al.* (2016) and Raundal *et al.* (2017) who reported the higher values of yield contributing character with higher application of N, P and K doses. Lower grain yield was recorded under wider spacing because total number of plants per unit area was far lesser than with closer spacing. Similar findings were also reported by Rajesh (2011) and Anitha *et al.* (2015).

The date presented in Table 2 revealed that higher gross returns, net Returns and B:C ratio recorded in treatment receiving 125 % RDF with 30 cm row spacing (₹ 88443 ha^{-1}, ₹ 56857 ha^{-1} and 2.81, respectively) followed by 100 % RDF with 30 cm row spacing (₹ 77892 ha^{-1}, ₹ 46717 ha^{-1} and 2.51, respectively). Lowest values were obtained in the treatment receiving 100 % RDF with 45 cm row spacing (₹ 61012 ha^{-1}, ₹ 29943 ha^{-1} and 1.97, respectively). This could be due to the manifestation of higher grain and straw yields fetching of higher net returns at increased levels of fertilizer. The similar results are reported by Yadav *et al.* (2009), Jyothi *et al.* (2016) and Prakasha *et al.* (2017).

Interaction effects

Yield, yield attributes and economics of Kodo millet were not influenced by the interaction effect of dates of sowing, row spacing and fertilizer levels.

Conclusion

Kodo millet sown early on first fortnight of July recorded significantly higher yield attributes, grain yield, straw yield, gross returns, net returns and B:C ratio. Application of 125 per cent with 45 cm row spacing is advantageous in terms of individual plant performance. Whereas, application of 125 per cent RDF with 30 cm row spacing was found economical on obtaining higher yield and net returns with high B:C ratio. Interaction effect of dates of sowing, row spacing and fertilizer levels were found to be non-significant with respect to yield attributes, yield and economics.

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