OPTIMIZATION OF AGE OF SEEDLINGS AND SPACING TO ENHANCE THE PRODUCTIVITY AND PROFITABILITY OF KODO MILLET UNDER TRANSPLANTED CONDITION

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ABSTRACT

Field experiment was conducted at Annamalai University Experimental Farm, Annamalai Nagar, Tamil Nadu, India during Kharif Season (June to September, 2013) to optimize the age of seedlings and spacing to enhance the productivity and profitability of kodo millet under transplanted condition . The treatments comprised three ages of seedlings (20, 25 and 30 days) and four spacing (Farmer practice of direct sowing, 15 x 10, 20 x 10 and 25 x 10 cm). The experiment was laid out in randomized block design with factorial arrangements and replicated thrice. Among the three ages of seedlings and four spacing, 20 days old seedlings and spacing of 15 x 10 cm recorded higher values for growth attributes (Plant height, Number of tillers hill$^{-1,}$ Number of branches tiller^{-1} , Leaf area index (LAI), and Dry Matter Production (DMP)), yield attributes (Number of panicles hill$^{-1,}$ Number of grains panicle $^{-1}$ and Thousand grains weight) , Yield (grain and straw) and net return and return rupee^{-1} invested of kodomillet, respectively. The combined effect of age of seedlings and spacing, 20 days old seedlings planted at 15 x 10 cm registered its superiority over others for growth, yield attributes, yield of kodo millet. The same treatment combination recorded higher net return and return rupee^{-1} invested in kodo millet. Thus, it is concluded that adoption of transplanting of 20 days old seedlings with 15 x 10 cm spacing holds immense potentiality to boost the productivity and profitability of kodo millet under transplanted.

Key words: age of seedlings, spacing, kodo millet, growth, yield and economics

I.INTRODUCTION

Kodo millet *(Paspalum scrobiculatum* L.) is one of the major food crops in tribal areas of the country. It is known to have been grown in southern Rajasthan and Maharashtra for at least 3,000 years (De Wet *et al*., 1983). It is found across the old world in humid habitats of tropics and subtropics. It is a minor grain crop in India and an important crop in the Deccan plateau. Wider adaptability, easy cultivation, ability to tolerate the biotic and abiotic stresses has made this crop as a major component of dry farming ecosystem. Kodo is grown mostly in Uttar Pradesh, Madhya Pradesh, Maharashtra, Andhra Pradesh, Kerala, Karnataka and Tamil Nadu. This cereal is known also as varagu , kodo , haraka and arakalu. It forms the main stay of the dietary nutritional requirements of farmers of marginal and dry lands in many parts of India. The fiber content of the whole grain is very high. Kodo millet has around 11% protein, and the nutritional value of the protein has been found to be slightly better than that of foxtail millet but comparable to that of other small millets. As with other food grains, the nutritive value of Kodo millet protein could be improved by supplementation with legume protein.

It occupies an area of 9.08 lakh ha with an annual production of 3.11 lakh tones and average productivity of 342 kg/ha. Among the small millets, productivity per unit area is highest in kodo millet (Ahamed and Yadava, 1996). It matures in 3-4 months with yields varying from 250 to 1000 kg/ha (Hulse *et al*., 1980) and a potential yield of 2000kg/ha (Harinarayana, 1989).

Now a day's kodo grain is recommended as a substitute for rice next to finger millet to patients suffering from diabetes diseases. Diabetes mellitus is a silent disease and is now recognized as one of the fastest growing threats to public health in almost all countries of the world. Around 150 million people suffer from diabetes in the world, of which above 35 million are Indians, the highest number in any country. Diabetes is on an increase in India. The revised World Health Organization figure for the year 2025 is 57.2 million diabetics (Vanithasri *et al.*, 2012). Within the allotted span, India shall also have the dubious distinction of having the maximum number of diabetics in the world. Further, the burgeoning population of our country may stabilize around 1.4 and 1.6 billions by 2025 and 2050, requiring annually 380 and 450 million tonnes of food grains respectively (Siddiq, 2000). Hence, there is an urgent need to increase the production and productivity of kodo millet to meet future food requirements and health benefit.

But kodomillet yields are either decelerating/stagnating/declining in India due to improper method of sowing/planting, imbalance in fertilizer use, inadequate weed management practices and lack of suitable genotypes for low and moisture adaptability. This crop respond very well even to small doses of inorganic fertilizers and other crop management practices, such as maintenance of adequate plant stand, timely weeding and inter cultivation. As far as kodo millet is concern, no work has been done under transplanted conditions. Keeping the above facts in consideration, the present experiment was conducted to optimize the age of seedlings and spacing to enhance the productivity and profitability of kodo millet under transplanted condition.

II.MATERIALS AND METHODS

Experimental Site and Soil

The experiment was performed on a wetland field of Annamalai University Experimental Farm, (11º21' N and 79º44' E with an altitude of + 5.7 m a. m.s.l.), Annamalai Nagar during Kharif season (June to September, 2013). The experimental soil was clay loam with an organic matter content of 0.51% and pH of 7.6. The Available N, P and K were 235.21, 18.74, 322.01 kg ha^{-1}, respectively.

Treatment Details and Design

The following is the detail of the treatments investigated in the experiment:

Factor- I: Age of seedlings (A)

A_1 - 20 days
A_2 - 25 days
A_3 - 30 days

Factor- II: Spacing (S)

S_1 - Control (Farmer practice of direct sowing)
S_2 - 15 x 10 cm
S_3 - 20 x 10 cm
S_4 - 25 x 10 cm

The experiment was laid out by adopting factorial randomized block design (FRBD) with three replications.

Crop Husbandry

Spacing and Seed rate

Crop	Spacing (cm x cm)	Seed rate (kg ha^{-1})
Kodo millet Variety - CO 3	Direct sowing	12
	15 x 10	9
	20 x 10	7
	25 x 10	5

Nursery preparation

The nursery bed was prepared by raising raised bed of 3 x 1.5 m in size and 15 cm height. Di-ammonium phosphate @ 2 kg $cent^{-1}$ was applied as basal. The kodo millet seeds were stored in gunny bag, soaked in water for 12 hours and seed treatment was done with *Azospirillum* @ 600 g ha^{-1}. The treated seeds were broadcasted in the nursery (500 m^2 ha^{-1}). The powdered FYM @ 500 kg ha^{-1} was spreaded evenly to cover the seeds. Urea @ 2 per cent spray was given on 7 DAS for better establishment of seedlings. Need based irrigation and plant protection measures were followed for controlling insect pests and diseases in transplanted kodo millet crop.

Main field preparation and Transplanting

The field was ploughed at optimum moisture condition with tractor mounted mould board plough followed by rotovator to break clods to get a fine tilth. Beds of 4 x 3 m, bunds and channels were formed manually. Field was irrigated before transplanting, then seedlings were uprooted from the nursery on 20, 25 and 30 days after sowing and transplanted in the main field by adopting the spacing of 15 x 10 cm, 20 x 10 cm and 25 x 10 cm respectively. The biofertilizer treated kodo millet seeds were broadcasted in the control plots initially 30 days prior to transplanting.

The kodo millet crop was fertilized with 44:22:0 kg of N, P_2O_5 and K_2O ha^{-1} in the form of urea (46% N) and DAP (18% N and 46% P_2O_5) during the crop. The entire dose of P_2O_5 and half of the dose of N was applied as basal. The remaining half of N was top dressed in two equal splits at active tillering and flowering stage. The crop was given adequate amount of irrigation at the time of transplanting/sowing and life irrigation on third day after transplanting/sowing. Subsequent irrigations were given once in 10 days as and when required.

Measurements

The growth attributes (Plant height, Number of tillers $hill^{-1,}$ Number of branches $tiller^{-1,}$ Leaf area index (LAI), and Dry matter production (DMP)), yield attributes (Number of panicles $hill^{-1,}$ Number of grains panicle $^{-1}$ and Thousand grain weight) were recorded from tagged plants, the yields (grain and straw) were recorded from the net plot area after enough sun drying and expressed in kg $ha^{-1.}$

Economics

The benefit cost ratio was worked out for various treatments by dividing the gross returns by cost of cultivation.

Statistical analysis

The data on various characters studied during the investigation were statistically analyzed as suggested by Gomez and Gomez (1984) and wherever the treatment differences were found significant (F test); critical differences were worked out at five per cent probability level.

III.RESULTS AND DISCUSSION

The data on growth, yield attributes, yield of kodo millet is given in Table 1 and 2.

Growth attributes

The growth attributes such as plant height, number of tillers $hill^{-1}$, LAI, and DMP were significantly influenced with age of seedling. Among the different age of seedlings, the younger seedlings recorded higher values for plant height, number of tillers $hill^{-1}$, LAI and DMP of transplanted kodo millet. The growth attributes were higher with 20 days old seedlings (A_1). This was followed by 25 days old seedlings (A_2). The highest plant height from younger seedlings might be due to more vigour, root growth and lesser transplant shock because of lesser leaf area during initial growth stages which stimulate increased cell division causing more stem elongation. Similar results were earlier reported by Jogi *et al.* (2013). The increase in number of tiller $hill^{-1}$ and LAI due to younger seedlings could be attributed due to quick establishment of plant, more effective use of light, nutrient and space and increased in photosynthetic rate of kodo millet. Similar results were reported by Pramanik and Bera (2013). The increase in DMP may be due to the increased plant height, number of tillers $hill^{-1}$ and better utilization of carbohydrates for growth and tissue building respectively (Zhong *et al.,* 1995). The lesser growth attributes were recorded with 30 days old seedlings. It might be due to ageing of older age seedlings, caused serious setback in their physiological activity, which resulted in poor growth. This is in agreement with the findings of Narsimha Rao and Pardhasarathi (1970) in finger millet.

With regards to spacing, planting of seedlings at 15 x 10 cm (S_2) recorded higher plant height, number of tillers $hill^{-1}$, LAI and DMP transplanted kodomillet. This was followed by S_3 (20 x 10 cm). Increase in plant height might owe to increased cell division, elongation and expansion caused by spacing due to effective utilization of applied nutrients and water. The higher values for LAI could be due to more number of leaves and tillers $hill^{-1}$ and also increased rate of photosynthesis in kodo millet. The dry matter production is an important parameter, which indicates the photosynthetic efficiency of plants. The DMP of kodo millet was higher with the spacing of 15 x 10 cm. It might be due to increased plant population due to closer spacing, increased number of tillers, LAI and increased the photosynthetic efficiency of kodo millet which induced to produce more DMP. This is in accordance with the earlier findings of Kalaraju *et al.* (2009) in finger millet. Farmers practice of direct sowing (control) recorded lesser value for plant height, number of tiller hill^{-1}, LAI and DMP of transplanted kodo millet.

The combined effect of age of seedlings and spacing significantly influenced the growth attributes of transplanted kodo millet. Planting of 20 days old seedlings at 15x10 cm (A_1S_2) significantly increased the growth attributes of transplanted kodo millet.

Yield attributes and Yield

Age of seedling and spacing adoption significantly influenced the yield attributes and yield of transplanted kodo millet. Among the different age of seedling, 20 days old seedlings (A_1) recorded higher number of panicles hill$^{-1,}$ number of grains panicle$^{-1,}$ test weight, grain and straw yield of transplanted kodo millet which was closely followed by 25 days old seedlings. The increase in yield attributing characters and yield could to be due to the proper crop growth development and assimilate synthesis in the grains. Higher grain and straw yield production in the younger seedlings might be attributed to the vigorous and healthy growth, development of more productive tillers hill^{-1} and leaves ensuring greater resource utilization as compared to older seedlings. Similar results were reported by Vijayakumar *et al*. (2005) in rice. The lowest values for yield attributes and yield were registered under the seedlings planted with 30 days age (A_3). The use of over aged seedlings retarded the general performance of crop and hence the yield reduced drastically. This is in agreement with the findings of BRRI (1981) in rice.

Spacing increased the yield attributes and yield of transplanted kodo millet. Among the different spacing tried, spacing at 15 x 10 cm (S_2) registered its superiority over others and recorded higher number of panicles hill^{-1}, number of grains panicles^{-1}, test weight, grain and straw yield in transplanted kodo millet. This could be due to vigorous growth, higher fertility of panicles and proper development of grains due to environmental factors such as nutrients, moisture and light. This is in conformity with the findings of Jashim *et al.* (2011) in rice. The lower yield is obtained with farmer practice of direct sowing (S_1) due to lesser plant population per unit area and lesser numbers of productive tiller hill^{-1}. These results are in lined with the findings of Rashid *et al.* (2009).

The yield attributes and yield of transplanting kodomillet was greatly influenced by age of seedlings and spacing. Among the different combination of age of seedlings and spacing, 20 days old seedlings along with the spacing of 15 x 10 cm (A_1S_2) significantly increased the yield attributes and yield of kodomillet. This was superior over 25 and 30 days seedlings planted at 20 x 10 and 25 x 10 cm respectively. The straw yield of kodo millet was also extensively influenced by the various treatments. Higher straw yield was recorded under 20 day's old seedlings at 15 x 10 cm. More plant population owing to closer spacing might have contributed to maximum DMP and LAI which ultimately enhanced the straw yield. This result is in conformity with the findings of Narsimhamurty and Hegde (1981) in finger millet.

Economics

The net return and return rupee^{-1} invested of transplanted kodo millet was greatly influenced by the age of seedlings and spacing (Table 3). The highest net return and return rupee^{-1} invested of Rs.34,582 and 2.72 was associated with the treatment A_1S_2 (20 days seedlings with 15 x 10 cm). This might to be due to optimum plant population maintained in an unit area which may leads to higher grain yield resulted in higher values for net return and benefit cost ratio resulted in more profit. This was followed by A_1S_3 (20 days seedling with 20 x 10 cm) which recorded a return rupee^{-1} invested of 2.35. The least net return and return rupee Rs.557 and 1.03 was observed under farmer practice of direct sowing.

IV.CONCLUSION

The experimental results enlightened that there was marked variation on the productivity of kodo millet under transplanted condition due to adoption of age of seedlings and spacing practices, 20 days old seedlings planted at 15 x 10 cm spacing produced better yield characters and yield besides being economically competitive and productive. Hence, it is concluded that adoption of transplanting of 20 days old seedlings with 15 x 10 cm spacing holds immense potentiality to boost the productivity and profitability of kodo millet under transplanted condition.

Table 1 Effect of age of seedlings and spacing on growth and yield attributes of kodomillet

Treatments	Growth attributes					Yield attributes		
	Plant height (cm)	No. of tillers hill^{-1}	No. of branches tiller^{-1}	LAI at flowering	DMP at harvest (kg ha^{-1})	No. of panicles hill^{-1}	No. of grains panicle $^{-1}$	Thousand grains weight (g)
Factor I- Age of seedlings(A)								
A_1	87.52	13.21	3.64	4.71	10970	45.09	195.02	6.54
A_2	82.10	11.28	3.45	3.21	9575	40.98	186.18	6.49
A_3	75.38	9.85	3.31	2.63	8127	34.12	167.27	6.47
S.Ed	1.36	0.27	0.22	0.07	134.93	0.59	0.77	0.02
CD(P=0.05)	2.82	0.56	NS	0.16	279.31	1.22	1.59	NS
Factor II- Spacing (S)								
S_1	62.77	5.17	1.75	1.98	5147	6.52	144.15	6.45
S_2	93.36	15.05	4.16	4.61	11525	54.10	202.23	6.53
S_3	87.01	13.18	4.03	4.02	10944	51.28	194.21	6.52
S_4	83.53	12.37	3.93	3.47	10614	48.26	190.60	6.50
S.Ed	1.57	0.31	0.25	0.04	155.81	0.68	0.89	0.02
CD(P=0.05)	3.26	0.65	NS	0.08	322.52	1.41	1.84	NS
A X S								
A_1S_1	63.93	5.63	1.78	2.00	5230	7.00	146.66	6.47
A_1S_2	103.56	18.73	4.50	6.91	13542	59.8	219.53	6.59
A_1S_3	92.16	14.36	4.20	5.44	12805	57.14	208.15	6.58
A_1S_4	90.45	14.12	4.10	4.52	12304	56.44	205.74	6.53
A_2S_1	63.00	5.06	1.75	1.98	5120	6.57	144.53	6.45
A_2S_2	89.54	13.84	4.06	3.90	11237	53.86	202.64	6.52
A_2S_3	88.87	13.26	4.01	3.77	11031	52.91	199.55	6.51
A_2S_4	87.01	12.97	3.98	3.22	10912	50.33	198.00	6.50
A_3S_1	61.40	4.83	1.73	1.97	5090	6.00	141.28	6.43
A_3S_2	86.99	12.60	3.92	3.04	9797	48.66	184.53	6.50
A_3S_3	80.02	11.93	3.88	2.85	8997	43.79	174.93	6.49
A_3S_4	73.14	10.04	3.71	2.67	8625	38.03	168.06	6.48
S.Ed	2.73	0.54	0.31	0.15	269.87	1.18	1.54	0.04
CD(P=0.05)	5.65	1.13	NS	0.32	558.63	2.45	3.19	NS

Table 2 Effect of age of seedlings and spacing on grain and straw yield of kodo millet

Treatment combination	Yield (kg ha^{-1})	
	Grain	**Straw**
Factor I- Age of seedlings(A)		
A_1	2514	7521
A_2	2188	6499
A_3	1712	5412
S.Ed	35.62	137.97
CD(P=0.05)	73.74	285.60
Factor II- Spacing (S)		
S_1	1044	3420
S_2	2694	7962
S_3	2474	7469
S_4	2338	7059
S.Ed	41.13	159.31
CD(P=0.05)	85.15	329.78
A X S		
A_1S_1	1106	3566
A_1S_2	3333	9425
A_1S_3	2867	8761
A_1S_4	2750	8333
A_2S_1	1069	3403
A_2S_2	2681	7944
A_2S_3	2528	7484
A_2S_4	2472	7166
A_3S_1	958	3290
A_3S_2	2070	6517
A_3S_3	2028	6163
A_3S_4	1792	5677
S.Ed	71.25	275.94
CD(P=0.05)	147.49	571.21

Table 3 Effect of age of seedlings and spacing on economics of kodo millet

Treatment combinations	Cost of cultivation (Rs.)	Gross income (Rs.)	Net income (Rs.)	Return Rupee^{-1} invested
A_1S_1	16372	18358	1986	1.12
A_1S_2	20125	54707	34582	2.72
A_1S_3	20125	47370	27245	2.35
A_1S_4	20125	45416	25291	2.26
A_2S_1	16372	18006	1634	1.09
A_2S_2	20095	44172	24077	2.20
A_2S_3	20095	41662	21567	2.07
A_2S_4	20095	40663	20568	2.02
A_3S_1	16372	16815	557	1.03
A_3S_2	20065	34293	14228	1.71
A_3S_3	20065	33501	13436	1.67
A_3S_4	20065	29719	9654	1.48

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