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The response of different Kodo millet (*Paspalum scrobiculatum* L.) varieties to varying levels of nitrogen fertilization

Kapil Xess and VK Singh

Abstract
The present experiment was entitled **"**The response of different Kodo millet (*Paspalum scrobiculatum* L.) varieties to varying levels of nitrogen fertilization" was carried out at research farm of RMD College and Research Station Ajirma Surguja (C.G.) during the kharif season of 2022 to find out the appropriate variety and nitrogen level to gate higher grain and economics of kodo for northern hill region of Chhattisgarh. Treatment consisting three kodo varieties *viz.* Indira kodo-1,C.G. kodo-2 and C.G. kodo-3 and three nitrogen levels *viz.*40, 60 $a\wr\wr$ 80 $kg\ \wr itr\wr g\wr\wr\ ha^{-1}$. Among the three varieties C.G. Kodo-3 produce significantly higher Growth parameters and yield attribute characters, grain yield 2966$Kg\ ha^{-1}$, straw yield 5756$Kg\ ha^{-1}$ andbiological yield 8724 $Kg\ ha^{-1}$ and registered 17 and 7.5 percent higher grain yield over Indira kodo-1 and C.G. kodo-2 ha^{-1}. Among the three nitrogen levels 80 kg ha^{-1} produce significantly higher Growth characters and yield attributes character, grain yield 2892$Kg\ ha^{-1}$, straw yield 5785$Kg\ ha^{-1}$ and biological yield 8679 $Kg\ ha^{-1}$ and registered 13.34 and 6.59 percent higher grain yield over 40 and 60 kg nitrogen ha^{-1}. The study indicated an improvement in growth characters, yield attributes, yield, economics and benefit: Cost ratio under kodo variety C.G. kodo-3 at 80 kg nitrogen h^{-1} with its overall benefit as compared to other varieties and preceding levels of nitrogen.

Keywords: C.G. Kodo-3, C.G. Kodo-2, Nitrogen fertilization, growth, yield and economics

Introduction
Kodo is grown in West Africa, Nepal, India, Philippines, Indonesia, Vietnam and Thailand. It probably started domesticating three thousand years ago in India. In Indian this crop is grow in Rajasthan, Madhya Pradesh, Uttar Pradesh, West Bengal, Tamil Nadu, Chhattisgarh, Maharashtra, Karnataka, and Adhra Pradesh in area about 1.96 lakh ha and produced more than 0.84 lakh tonnes with a productivity of 429 kg h^{-1} (Coordinating the project, under ICAR (AICRP) on Small Millets, at GKVK, Bengaluru 2019). Kodo millet contains a lot of nutrients per 100 g, including 65 g of carbohydrates, 8.30 g of protein, 1.40 g of fat, 2.9 g of ash, 27.0 mg of calcium, 0.5 mg of iron, 0.7 mg of zinc, 0.09 mg of riboflavin, 0.33 mg of thiamine, 23.1 mg of folic acid, and 9.0 g of fibre (Gopalan *et al*. 1989) [19]. Nitrogen plays a critical role in the function of every living cell as a component of protoplasm. Due to the tropical climate, Indian soils contain very little nitrogen. Nitrogen is applied to non-leguminous crops to increase grain yield and is heavily needed. Several workers have been reported that nitrogen requirement to this crop to be 20-40 to 60 kg $ha^{-1}$for different farming conditions exist in various regions of the nation. Thakur *et al.* (1999) [17], Raja (2005) [15] and Dubey (1991) [8]. The nitrogen requirement for improved and high yielding varieties for light texture (sandy loam soil) for northern hill region of Chhattisgarh is lacking. Hence current investigation was conducted.

Methods and Materials
The research was conduct at the research farm of RMD College and Research Station, Ajirma, Surguja (C.G.). during the *kharif* season of 2022. Treatment consisting three kodo varieties (Indira kodo-1, C.G. kodo-2, C.G. kodo-3) and three nitrogen levels (N1= 40, N2 = 60 and N3= 80 kg nitrogen ha^{-1}) were laid out in experimental setup followed a Factorial-Randomized Block Design (FRBD) with three replications. The crop was sown on 6 July 2022 with seed rate 8 Kg ha^{-1} at row spacing 22.5 cm. All the recommended package of practices adopted as condition of northern hill region of Chhattisgarh.

Result and Discussion

Performance of Varieties Growth character

Among the variety C.G. Kodo-3 had significant effects on growth parameters *viz.* plant height (cm), number of tillers m^{-1}, number of effective tillers m^{-1}, dry-matter accumulation (g $plant^{-1}$), crop growth rate (g $plant^{-1}$) at all stages of observation, compare to C.G. Kodo-2 and Indira Kodo-1.The differences in response among the kodo varieties could be attributed to variations in the genetic makeup, such as differences in internodal length, nutrient absorption capacity, and ability to convert radiant energy into biochemical energy through chlorophyll photosynthesis. Additionally, the results are consistent with the findings reported by Bhomte *et al.* (2013) [21], Patil *et al.* (2015) [22], Jyothi *et al.* (2016b) [23] and Nandini and Sridhara (2019) [24].

Yield attributes

The yield attributes character also significantly higher in variety C.G. Kodo-3 *viz*., the number of grainspanicle^{-1}, panicle weight (g), panicle length (cm), grain yield (g $plant^{-1}$), 1000seed weight (g). Different varieties have different genetic potential, which is crucial for defining yield attributes character and for enhancing assimilate partitioning from source to sink, could be the cause of this. The present results corroborate previous evidence which demonstrated that genetic constitution defines a variety's natural propensity for enhanced yield traits. This allows maximization of photosynthate partitioning towards economic yield, as exhibited by C.G. Kodo-3 in the current study. Its constitution seemed optimally tuned to express ideal sink strength and translocation efficiency from source to sink. This gives C.G. Kodo-3 an advantage over other varieties for attaining higher grain productivity. Similar conclusions were reached by Rao *et al.* (1987) [25], Intodia (1994) [26], and Triveni *et al*. (2018) [20].

Yield

C.G. Kodo-3 significantly highest grain, straw, and biological yield was produced*viz.*2966, 5756 and 8724 kg ha^{-1} respectively. Indira kodo-1 produce 2452, 5513 and 7966 kg ha^{-1} of the grain, straw and biological yield. C.G. kodo-2 produced 2743, 5617 and 8360 kg ha^{-1} of the grain, straw and biological yield. That was 17 and 7.5 percent higher grain yield over Indira kodo-1 and C.G. kodo-2, respectively. The superior performance of C.G. Kodo-3 can be attributed to its higher number of effective tillers, dry matter production, panicle length and panicle weight observed in the study. These yield contributing traits favorably influenced the grain yield of C.G. Kodo-3. Similar findings have been reported by previous researchers where genotypic variations led to differences in yield attributes and productivity. Intodia (1994) [26] found yield variations among finger millet varieties due to genetic effects on yield traits. Dwivsion and Choudhary (2000) also observed variability in panicle traits and yields in finger millet. Munirathnam *et al.* (2006) [27], Singh and Maurya (2013) [28] and Triveni *et al.* (2018) [20] further reported genotypic influence on productivity through modulated sink capacity and yield components.

Economics

The C.G. kodo-3 variety produced significantly higher gross returns (94,752₹ ha^{-1}), Net returns (Rs. 60,417₹ ha^{-1}), and Benefit-cost ratio (1.75) compared to the Indira kodo-1 and C.G. kodo-2 varieties. The results concur with previous reports demonstrating varietal differences in kodo millet for productive efficiency and economic productivity under fluctuating nutrient regimes. Specifically, C.G. Kodo-3 proved most remunerative among the tested varieties when supplied with optimal nitrogen levels through fertilization. Also, similar study found by Triveni *et al*. (2018) [20].

Performance of Nitrogen levels

Growth character-80 kg nitrogen ha^{-1} had significant effects on growth parameters *viz*. plant height in cm, number of tillers m^{-1}, number of effective tillers m^{-1}, dry matter accumulation (g $plant^{-1}$), crop growth rate (g $plant^{-1}$) at all stages of observation, compare to 40 and 60 kg nitrogen ha^{-1}. This may be because increasing nitrogen levels led to better photosynthesis, increased plant height, improved crop growth, and a greater number of tillers that might accumulate more dry matter. This study's findings about increased dry matter production with larger nitrogen doses are consistent with those of Hasan *et al*. (2013) [29], Basavarajappa *et al.* (2002) [30] and Naik *et al.* (1995) [31].

Yield attributes

The yield attributes character also significantly higher in 80 kg nitrogen ha^{-1} *viz*., effective tillers 178 m^{-1}, panicle length 15.4 cm, panicle weight 7.26 g, number of grain panicle^{-1} 250.00 and test weight 5.0 g compare to 40 and 60 kg nitrogen ha^{-1}

Yield

The application of 80 kg nitrogen ha^{-1}resulted in significantly highest grain, straw and biological yield 2892, 5785 and 8679 kg ha^{-1} respectively. 40 kg nitrogen ha^{-1} produce 2555, 5467 and 8022 kg ha^{-1} of the grain, straw and biological yield. C.G. kodo-2 produced 2714, 5634 and 8348 kg $ha^{-1}$of the grain, straw and biological yield. That was 13.34 and 6.5 percent higher grain yield over 40 and 60 kg nitrogenha^{-1}, respectively.

Economics

The application of 80 kg nitrogen per hectare produced significantly higher gross return (92571₹ ha^{-1}), net return (58002₹ ha^{-1}) and B:C (1.68) ration were recorded from 80 kg nitrogen ha^{-1}over 40 and 60 kg nitrogen ha^{-1}.These superior returns can be attributed to the increased grain, straw and biological yields recorded with 80 kg N/ha application. Optimal nitrogen levels help meet the nutrient demands of crops, thereby promoting better vegetative growth, increased photosynthetic capacity and yield attributes. Previous studies have also reported yield and economic enhancements with balanced nitrogen nutrition. Optimal nitrogen nutrition plays a key role in improving crop growth and productivity by supporting various physiological processes such as photosynthesis. Previous studies have also reported yield and monetary advantages with balanced nitrogen management. Ahmed *et al.* (2003) [2] found 90 kg N/ha to be most remunerative for finger millet. Similarly, Singh *et al.* (2013) [16] observed peak profits in pearl millet at 80 kg N/ha due to yield augmentation.

Table 1: Plant population influence by varieties and nitrogen levels

Treatments	Plant population ⁻¹		Mortality rate (%)
	20 DAS	At harvest	
Varieties			
Indira kodo-1	15.8	15.2	3.8
C.G. Kodo-2	15.9	15.2	4.3
C.G. Kodo-3	16.0	15.3	4.4
S.Em ±	0.1	0.2	0.8
CD (5%)	NS	NS	NS
Nitrogen Levels (kg ⁻¹)			
40	15.7	15.0	4.4
60	15.9	15.2	4.2
80	16.1	15.4	4.0
S.Em ±	0.1	0.2	0.8
CD (5%)	NS	NS	NS
Interaction			
S.Em ±	0.2	0.3	1.4
CD (5%)	NS	NS	NS

Table 2: Growth characters of kodo millet influence by varieties and nitrogen levels

Treatments	Plant height (cm)	Number of tillers⁻¹	Effective tillers ⁻¹	Dry matter accumulation (g p⁻¹)
Varieties				
Indira kodo-1	134.5	164.9	160.5	8.8
C.G. Kodo-2	139.0	169.9	164.9	8.9
C.G. Kodo-3	144.3	174.7	171.3	9.1
S.Em ±	0.4	0.6	0.8	0.15
CD (5%)	1.3	1.7	2.3	0.46
Nitrogen Levels (kg ⁻¹)				
40	137.1	157.4	155.1	8.0
60	139.1	169.8	164.6	8.4
80	141.5	182.3	177.0	9.5
S.Em ±	0.4	0.6	0.8	0.15
CD (5%)	1.3	1.7	2.3	0.46
Interaction				
S.Em ±	0.7	1.0	1.3	0.26
CD (5%)	NS	NS	NS	NS

Table 3: The yield attributes characters of kodo milletwere influenced by variety and nitrogen level.

Treatments	Number of grain pa⁻¹	Panicle weight in (g)	Panicle length in (cm)	1000-seed weight in (g)
Varieties				
Indira kodo-1	207.1	6.6	13.9	4.8
C.G. Kodo-2	237.2	6.6	14.6	4.8
C.G. Kodo-3	277.0	7.2	14.9	5.0
S.Em ±	1.4	0.04	0.2	0.02
CD (5%)	4.3	0.11	0.3	0.06
Nitrogen Levels (kg ⁻¹)				
40	229.8	6.4	13.5	4.8
6	240.7	6.8	14.5	4.9
80	250.8	7.26	15.4	5.0
S.Em ±	1.4	0.037	0.2	0.02
CD(5%)	4.3	0.053	0.3	0.06
Interaction				
S.Em ±	2.4	0.06	0.3	0.03
CD (5%)	NS	NS	NS	NS

Table 4: Yield of kodo millet were influenced by variety and nitrogen level.

Treatments	Grain yield (kg ⁻¹)	Straw yield (kg ⁻¹)	Biological yield (kg ⁻¹)	Harvest index (%)
Varieties				
Indira kodo-1	2452	5513	7966	30.7
C.G. Kodo-2	2743	5617	8360	32.7
C.G. Kodo-3	2966	5756	8724	33.9
S.Em ±	17	18	29	0.1
CD (5%)	51	57	89	0.4
Nitrogen Levels (kg ⁻¹)				
40	2555	5467	8024	31.8

60	2714	5634	8348	32.4
80	2892	5785	8678	33.2
S.Em ±	17	18	29	0.1
CD (5%)	51	57	89	0.4
Interaction				
S.Em ±	30	32	51	0.2
CD (5%)	NS	NS	NS	NS

Table 5: Economics of kodo millet influence were influenced by variety and nitrogen level

Treatments	Cost of cultivation (COC) (₹ ha^{-1})	Gross-return (₹ ha^{-1})	Net-return (₹ ha^{-1})	B:C Ratio
Varieties				
Indira kodo-1	34336	79090	44755	1.30
C.G. Kodo-2	34336	87917	53582	1.56
C.G. Kodo-3	34336	94752	60417	1.75
S.Em ±		518	518	0.02
CD (5%)		1567	1568	0.06
Nitrogen Levels (kg ha^{-1}))				
40	34100	82123	48023	1.40
60	34336	87064	52728	1.53
80	34569	92571	58002	1.68
S.Em ±		518	518	0.02
CD (5%)		1567	1568	0.06
Interaction				
S.Em ±		898	898	0.03
CD (5%)		NS	NS	NS

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