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Performance of nutri-rich millets in pigeonpea intercropping system under Northern dry zone of Karnataka

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Abstract
A field experiment was conducted during *Kharif* 2021 and *Kharif* 2022 at Krishi Vigyan Kendra, Vijayapura, University of Agricultural Sciences, Dharwad to study the performance of nutri-rich millets in pigeonpea intercropping system in Northern Dry Zone of Karnataka under rainfed condition. The experiment was laid out in randomized block design with thirteen treatments comprising of six nutri-rich millets *viz*., barnyard millet, kodo millet, little millet, proso millet, browntop millet and teff with pigeonpea 1:2 row proportion and their sole crops replicated thrice. During both the years (2021 and 2022) pooled mean indicated that grain yield was recorded significantly higher in sole barnyard millet (1627 kg ha^{-1}, 1612 kg ha^{-1} and 1620 kg ha^{-1}, respectively) over intercropped treatments. Among intercropping system, pigeonpea + barnyard millet was noticed higher grain yield (1018 kg ha^{-1}, 989 kg ha^{-1} and 1004 kg ha^{-1}, respectively) and it was found on par with pigeonpea + kodo millet (957, 932 and 945 kg ha^{-1}, respectively). However, significantly. lower grain yield was recorded in pigeonpea + teff (112, 107 and 110 kg ha^{-1}, respectively). Sole barnyard millet recorded significantly. higher grain yield (1627, 1612 and 1620 kg ha^{-1}, respectively) and stover yield (3276 kg ha^{-1}) when compared to intercropped treatments. Among the intercropped treatments, economics of the systems also showed that pigeonpea + teff was most profitable system in terms of gross return (Rs.118188 ha^{-1}), net return (Rs.118188 ha^{-1}) and B: C ratio (2.63).

Keywords: Intercropping, yield, teff, nutri-rich millets and B:C ratio

Introduction
Nutri-rich millets and pigeonpea are important *Kharif* crops on shallow to medium deep black soil of Northern Dry Zone of Karnataka. Nutri-rich millets remains a staple cereal in arid and semi-arid regions due to its drought tolerance and early maturity, making it suitable for short-term catch cropping. It adapts well to various elevations, soils, and temperatures but cannot withstand waterlogging. Nutri-rich millets are quick growing and early maturing crop. Under the present system of cultivation the land and other resources are under utilized. The land use efficiency can be increased particularly after harvest of this crop, which can be efficiently utilized by adopting intercropping system. In intercropping system, the competitive effects between main and intercrop depends on the rooting pattern, canopy structure and days to maturity. Small millets cultivation is declining due to several reasons few of which are processing hardships, low economic gains and lack of awareness about the nutritional significance. The area under millets is declining at an alarming rate in spite of the favourable cultivation conditions available. Millets are suitable for arid lands with limited water and higher temperatures. Intercropping, growing multiple crops together, intensifies resource use and yields. Advantages include better resource utilization, weed suppression, yield stability, higher equivalent yields, increased cropping intensity, reduced pest and disease incidence, improved soil health, and sustainable farming. Intercropping in small millets enhances resource efficiency, yields, and sustainability, making it advantageous for agriculture in arid regions.

Material and Methods
The field experiment was conducted during *kharif* season for two year (2021 and 2022) at

ICAR-Krishi Vigyan Kendra, Vijayapura, University of Agricultural Sciences, Dharwad. It was laid out in RCBD with thirteen treatments and three replications. The treatments were T_1 = Pigeonpea (Sole), T_2 = Teff (Sole), T_3 = Barnyard millet (Sole), T_4 = Browntop millet (Sole), T_5 = Little millet (Sole), T_6 = Kodo millet (Sole), T_7 = Proso millet (Sole), T_8 = Pigeonpea + Teff (1:2), T_9 = Pigeonpea + Barnyard millet (1:2), T_{10} = Pigeonpea + Browntop millet (1:2), T_{11} = Pigeonpea + Little millet (1:2), T_{12} = Pigeonpea + Kodo mille (1:2), T_{13} = Pigeonpea + Proso millet (1:2). The soil of the experimental site is vertisol with slightly alkaline pH (8.37), organic carbon (0.52%), available nitrogen (188 kg ha^{-1}), available phosphorus (32 kg ha^{-1}) and available potassium (357 kg ha^{-1}).The data on growth and yield attributes were recorded. Statistical analysis was done as per the methodology suggested by Gomez and Gomez (1984) [5].

Results and Discussion

In the present investigation, nutri-rich millets were intercropped with pigeon pea. Two rows of nutri-rich millets between a row of pigeonpea had significantly influenced nutri-rich millets performance. Among intercropped treatments, Pooled data revealed that pigeonpea + barnyard millet was noticed significantly higher number of panicles (12.57) and higher panicle weight (5.42 g) it was found on par with pigeonpea + kodo millet (4.96 and 5.18 g, respectively). Significantly. lower number of panicles and lower panicle weight was recorded under pigeonpea + teff (3.03 and 3 g, respectively) when compared to other intercropped treatments. Pooled data revealed that significantly. higher stover yield was recorded under sole barnyard millet (3276 kg ha^{-1}) over intercropped treatments *viz*., pigeonpea + barnyard millet (2042 kg ha^{-1}) and pigeonpea + kodo millet (1922 kg ha^{-1}) were on par with one another. However, significantly. lower stover yield was recorded under pigeonpea + teff (243 kg ha^{-1}) when compared to other intercropped treatments. During both the years (2021 and 2022) pooled mean indicated that grain yield was recorded significantly higher in sole barnyard millet (1627, 1612 and 1620 kg ha^{-1}, respectively) over intercropped treatments. Among intercropping system, pigeonpea + barnyard millet was noticed higher grain yield (1018, 989 and 1004 kg ha^{-1}, respectively) and it was found on par with pigeonpea + kodo millet (957, 932 and 945 kg ha^{-1}, respectively). However, significantly.lower grain yield was recorded in pigeonpea + teff (112, 107 and 110 kg ha^{-1}, respectively) (Table 1). The similar results were also observed by Kumar *et al.* (2012) [7] and Sharma *et al.* (2010) [9]. The significantly higher yield of barnyard millet under sole cropping could be attributed to higher population and competition free environment as compared to intercropped barnyard millet which resulted in better growth and yield components in sole crop. Similar results were observed by Dubey and Shrivas (1997) [4] in kodo millet + pigeonpea or soybean or black gram, Jadhav *et al.* (1990) [6] in pearl millet + green gram, Balasubramanian *et al.* (1984) [3] in pearl millet + pulses, Ahamad and Prasad (1996) [1] in little millet + pigeonpea or groundnut and Shashidhar *et al.* (2000) [10] in little millet + pigeonpea.

The gross returns, net returns and B:C ratiowere recorded under different treatments are presented in Table 2. The pooled data revealed that sole pigeonpea recorded highest gross returns (Rs. 89991 ha^{-1}) over the intercropped treatments and sole crops of barnyard millet, browntop millet, little millet, kodo millet, proso millet and teff. Among the intercropped treatments Pigeonpea + teff (Rs.118188 ha^{-1}) higher gross returns followed by pigeonpea + barnyard millet (Rs.105778 ha^{-1}), Pigeonpea + Kodo millet (Rs.99999 ha^{-1}), Pigeonpea + Little millet (Rs.98744 ha^{-1}), Pigeonpea + Proso millet (Rs.98640 ha^{-1}) and pigeonpea + browntop millet (Rs.92470 ha^{-1}). However, significantly highest net returns (Rs.51857 ha^{-1}) over the sole crops of barnyard millet, browntop millet, little millet, kodo millet, proso millet and teff. Among the intercropped treatments, pigeonpea + teff (Rs.118188 ha^{-1}) was recorded significantly higher net returns over pigeonpea + browntop millet (Rs.47091 ha^{-1}). Significantly higher benefit cost ratio was noticed in sole teff (2.71) over the intercropped treatments and sole crops of pigeonpea, barnyard millet, browntop millet, little millet, kodo millet and proso millet. Among the intercropped treatments Pigeonpea + teff (2.63) was recorded significantly higher benefit cost ratio than pigeonpea + browntop millet (2.04). This might due to higher seed yield with higher market price of pigeonpea and teff ensured the higher gross returns under pigeonpea + teff intercropping systems over other intercropping systems. Whereas, respective sole stand of all intercrops observed lesser gross returns over their respective intercropped systems. A similarly significantly higher net return was recorded in intercropping of pigeonpea with teff. Finally in terms of economic net returns pigeonpea + teff accrued benefits higher. Similar results of higher net returns were reported with pigeonpea based intercropping systems by Tiwari *et al.* (2016) [11] and Arjun Sharma and Guled (2011) [2]. With respect to B:C ratio, the significantly higher benefit cost ratio was recorded with pigeonpea + teff intercropping system. However significantly lower benefit cost ratio was recorded under sole browntop millet over their respective intercropping systems. The higher B:C ratio under pigeonpea + teff was due to higher market price of pigeonpea and teff when compared toother crops. Similar results were reported by Pawar *et al.* (2013) [8].

Table 1: Number of panicle plant^{-1}, length of panicle (cm), weight of panicle (g) and test weight (g) of nutri-rich millets at different growth stages as influenced by pigeonpea and nutri-rich millets intercropping system.

Treatments	Number of panicle plant^{-1}			Panicle weight (g)			Grain yield (kg ha^{-1})			Stover yield (kg ha^{-1})		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
T_1. Pigeonpea (Sole)	-	-	-	-	-	-	-	-	-	-	-	-
T_2. Teff (Sole)	4.23	4.09	4.16	3.82	3.51	3.67	182	171	177	395	372	384
T_3. Barnyard millet (Sole)	7.15	7.01	7.08	9.12	9.01	9.07	1627	1612	1620	3291	3260	3276
T_4. Browntop millet (Sole)	6.32	6.19	6.26	8.50	8.31	8.41	1551	1538	1545	3127	3100	3114
T_5. Little millet (Sole)	6.53	6.37	6.45	8.71	8.48	8.60	1564	1541	1553	3156	3109	3133
T_6. Kodo millet (Sole)	6.91	6.87	6.89	9.01	8.81	8.91	1595	1582	1589	3220	3193	3207
T_7. Proso millet (Sole)	6.72	6.61	6.67	8.83	8.65	8.74	1571	1553	1562	3174	3134	3154
T_8. Pigeonpea + Teff (1:2)	3.10	2.96	3.03	3.04	2.95	3.00	112	107	110	248	237	243
T_9. Pigeonpea + Barnyard millet (1:2)	5.21	5.03	5.12	5.71	5.12	5.42	1018	989	1004	2071	2012	2042
T_{10}. Pigeonpea + Browntop millet (1:2)	4.42	4.21	4.32	4.81	4.05	4.43	852	838	845	1734	1704	1719
T_{11}. Pigeonpea + Little millet (1:2)	4.61	4.43	4.52	4.98	4.16	4.57	902	879	891	1834	1785	1810
T_{12}. Pigeonpea + Kodo mille (1:2)	5.02	4.89	4.96	5.42	4.93	5.18	957	932	945	1948	1896	1922
T_{13}. Pigeonpea + Proso millet (1:2)	4.87	4.62	4.75	5.17	4.48	4.83	923	901	912	1879	1833	1856
S.Em±	0.10	0.13	0.11	0.15	0.20	0.16	30	28	23	42	38	41
C.D (P = 0.05)	0.32	0.40	0.35	0.45	0.61	0.49	92	84	71	125	118	123

Table 2: Cost of cultivation (Rs. ha^{-1}), gross returns (Rs. ha^{-1}), net returns (Rs. ha^{-1}) and benefit cost ratio as influenced by 1:2 row proportion in pigeonpea and nutri rich millets intercropping system

		Cost of cultivation (Rs. ha^{-1})			Gross returns (Rs. ha^{-1})			Net returns (Rs. ha^{-1})			Benefit cost ratio		
Tr. No.	Treatment detail	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
T_1	Pigeonpea (Sole)	37147	39122	38135	91002	88980	89991	53855	49858	51857	2.45	2.27	2.36
T_2	Teff (Sole)	18944	20144	19544	54600	51300	52950	35656	31156	33406	2.88	2.55	2.71
T_3	Barnyard millet (Sole)	19559	20784	20172	35794	37076	36435	16235	16292	16264	1.83	1.78	1.81
T_4	Browntop millet (Sole)	19509	20734	20122	29032	30460	29746	9523	9726	9625	1.49	1.47	1.48
T_5	Little millet (Sole)	19314	20513	19914	35604	37056	36330	16290	16543	16417	1.84	1.81	1.82
T_6	Kodo millet (Sole)	19522	20734	20128	30305	31760	31033	10783	11026	10905	1.55	1.53	1.54
T_7	Proso millet (Sole)	19534	20734	20134	31420	32697	32059	11886	11963	11925	1.61	1.58	1.59
T_8	Pigeonpea + Teff (1:2)	43819	46066	44943	117816	118560	118188	73997	72494	73246	2.69	2.57	2.63
T_9	Pigeonpea + Barnyard millet (1:2)	44127	46706	45417	104988	106567	105778	60861	59861	60361	2.38	2.28	2.33
T_{10}	Pigeonpea + Browntop millet (1:2)	44102	46656	45379	92980	91960	92470	48878	45304	47091	2.11	1.97	2.04
T_{11}	Pigeonpea + Little millet (1:2)	44004	46435	45220	98835	98652	98744	54831	52217	53524	2.25	2.12	2.18
T_{12}	Pigeonpea + Kodo millet (1:2)	44108	46656	45382	99557	100440	99999	55449	53784	54617	2.26	2.15	2.20
T_{13}	Pigeonpea + Proso millet (1:2)	44114	46656	45385	98268	98061	98165	54154	51405	52780	2.23	2.10	2.16
	S.Em±	-	-	-	-	-	-	2298	2930	1880	0.07	0.04	0.09
	C.D(P = 0.05)	-	-	-	-	-	-	6891	8791	5639	0.21	0.14	0.29

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Conclusion
The present study clearly indicate that intercropping of pigeonpea + teff at 1:2 row ratio is the best combination for getting higher yield and economic advantage followed by pigeonpea + barnyard millet under same row ratio.

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