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Effect of different herbicidal weed management on yield and economic of kodo (*Paspalum scrobiculatum* L.)

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Abstract
The present experiment was carried on the performance of kodo at the Instructional cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during *Kharif* seasons 2021 and 2022 The field experiment was laid out of kodo (Indira kodo 1) was growing variety for test crop in Randomized block design (RBD) with 10 treatment and 3 replications. The crop was sown manually on seedcum fertilizers 1 July 2021and 2 July 2022 after the onset of monsoon. The result of the experiment revealed that, different weed management practices on seed yield, straw yield, harvest index (%), economics of different herbicide application of kodo reveals that T_9: Green manuring up to 40 DAS required highest cost of cultivation than hand weeding twice 20 and 40 DAS and lowest cost of cultivation in control. Seed yield, straw yield, harvest index (%) (Mean *viz.*, 2044 and 4073 kg ha^{-1} and 33.41), gross return (Mean *viz.*, 61060Rsha^{-1}), net return (Mean *viz.*, 36354Rs ha^{-1}) and B: C ratio (Mean *viz.*, 2:46) was significantly higher under(T_5) Pyrazosulfuron ethyl 10% 20 g/ha (PE) *fb* Chlorimuronethyl 10% + Metsulfuron methyl 10% 4 g/ha (PoE) while minimum was recorded under T_{10}: control during both years and on mean value.

Keywords: Kodo, yield, chemicals, gross returns, net returns and B: C

Introduction
Millets are highly nutritious, non-glutinous and non-acid forming foods. Millets are two types: major millets and minor millets. Major millets are maize, bajra, sorghum, and minor millets are Kodo, Kutki, Ragi. Finger millet also known as ragi or mandua, valued as staple food and first important crop among small millets. Finger millet is believed to have originated in African highlands of Uganda and Ethiopia (Seetharam, 1997) [3], around 3,000 years BC and spread to India around 3,000 year ago. Millets are staple food in the developing world, especially in the drylands of Africa and Asia. Most of the millets are indigenous to Africa and later domesticated to other parts of the world. Globally, millets are cultivated in 93 countries and only 7 countries have more than 1 M ha acreage of millets. In general, more than 97% of millets production and consumption is by developing nations. India is the largest producer of millets with 37.5% of the total global output followed by Sudan and Nigeria (Meena *et al*. 2021) [2]. The *Paspalum genus* has more than 400 species, usually an annual crop, however many cultivars root at the nodes and grow culms after the mature plant flowers and matured their inflorescence. Some of the species are perennial in nature (De Wet *et al*., 1983) [5]. This crop is drought tolerant and usually grown in semi-arid regions without any intercultural operations. Kodo is monocot and the seeds are very small and ellipsoidal, being approximately 1.5mm in width and 2mm in length; they vary in colour from being light brown to a dark grey. Kodo millet has a shallow root system which may be ideal for intercropping. The grain is enclosed in hard, corneous, persistent husks (FAO, 1995) [6]. It is known as haraka (in Kannada), cow grass, rice grass, ditch millet, native paspalum, Indian crown grass, known to be originated from tropical Africa, and it is estimated to be domesticated in India 3000 years ago.

Materials and Methods

Geographical situation

The field experiment was carried out at Research cum Instructional Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh). Geographically, Raipur is situated in central parts of Chhattisgarh and lies at latitude, longitude and altitude of 21º4'N, 81º35' E and 290.20 meters above mean sea level, respectively.

Experimental site

The experimental site was located at the Instructional cum Research Farm, College of Agriculture, I.G.K.V. Raipur (C.G.). The experiment has been conducted in randomized block design with three replications. The treatments were *viz* T_1**:** Pyrazosulfuron ethyl 10% 20 g/ha (PE), T_2: Chlorimuron ethyl 10% + Metsulfuron methyl 10% 4 g/ha (PoE), T_3: Metsulfuron methyl 20% 4 g/ha (PoE), T_4: Carfentrazone ethyl 40% 12.5 g / ha. (PoE), T_5: Pyrazosulfuron ethyl 10%20 g/ha (PE) *fb* Chlorimuron ethyl 10% +Metsulfuronmethyl10% 4 g/ha (PoE), T_6: Pyrazosulfuron ethyl 10% 20 g/ha (PE) *fb* Metsulfuron methyl 20% 4 g/ha (PoE), T_7: Pyrazosulfuron ethyl 10% 20 g/ha (PE) *fb* Carfentrazone 40% 12.5 g / ha. (PoE), T_8**:** Hand weeding twice 20 and 40 DAS, T_9**:** Green manuring up to 40 DAS and T_{10}: Control.

Results and Discussion

The result of the experiment revealed that, all the yield *viz*., Seed yield, Straw yield and harvest index (%) were significantly higher (Mean *viz.*, 2044 and 4073 kg ha^{-1} and 33.41) under (T_5) Pyrazosulfuron ethyl 10% 20 g/ha (PE) *fb* Chlorimuron ethyl 10% + Metsulfuron methyl 10% 4 g/ha (PoE) which was followed by (T_8) hand weeding twice 20 and 40 DAS, (T_{10}) control was recorded lowest during both the years and in mean data. Application of metsulfuron methyl + chlorimuron-ethyl @ 4 g ha^{-1} at 7 DAS followed by hand weeding at 40 DAS resulted in significantly higher yield (2034 kg ha^{-1}) compared to other treatments (Gopinath and Kundu, 2008) [7]. Metsulfuron methyl @ 8 g ha^{-1} and metsulfuron methyl + chlorimuron ethyl @ 8 ha^{-1} not only provided higher yield among the treatments but their effectiveness for suppressing mixed flora of weeds was statistically comparable to weed-free condition and two hand weeding treatments (Singh *et al.,* 2012) [8]. Higher grain yield was attributed to better control of weeds, lower weed index and higher weed control efficiency throughout the crop growth period, which resulted in better availability of growth factors like light, space, nutrients and moisture to the crop resulting in better crop growth and yield. Similar results were also reported by s (Dhanapal *et al.,* 2015) [9].

The result of the experiment revealed that, different weed management practices on economics of different herbicide application of kodo reveals that $T_{9:}$ Green manuring up to 40 DAS maximum cost of cultivation (Mean *viz.*, 39006Rs. ha^{-1}), the gross return emphasized that among the different herbicide weed management the maximum gross return, net return, B:C ratio was recorded under T_5: Pyrazosulfuron ethyl 10% 20 g/ha (PE) *fb* Chlorimuron ethyl 10% + Metsulfuron methyl 10% 4 g/ha (PoE) (Mean *viz.*, 61060, 36354Rs. ha^{-1} and 2:46). Similar result were also reported by (Tuti *et al*.2016) [4] and found that the highest benefit: cost ratio (1.39) was recorded in manual weeding at 20 DAS. Higher cost of cultivation in weed free plots and two manual weeding was cost effective due to engagement of more labourers for weeding. Herbicides are economical and cost effective in managing weeds during initial stages as compared to hand weeding. This indicated that use of herbicides prevented weed emergence from initial stages and consequently increased the yield over hand weeding. This increased yield provided higher monetary returns, similarly when compared to unweeded control, considering the gross returns and cost of weed management practices, the benefit accrued due to weed management was considerably higher similar observations were made by (Kumara *et al.* 2007) [1].

Table: 1: Seed yield, Straw yield (kg ha^{-1}) Harvest index (%), of Kodo Millets as Influenced by Different Weed Management Practices

Treatments		Seed yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Harvest index (%)		
		2021	2022	Mean	2021	2022	Mean	2021	2022	Mean
T_1	Pyrazosulfuron ethyl 10% 20 g/ha (PE)	1543	1560	1551	3290	3312	3301	31.92	32.01	31.97
T_2	Chlorimuron ethyl 10% + Metsulfuron methyl 10% 4 g/ha (PoE)	1651	1675	1663	3732	3781	3757	30.67	30.69	30.68
T_3	Metsulfuron methyl 20% 4 g/ha (PoE)	1610	1635	1622	3679	3732	3705	30.44	30.46	30.45
T_4	Carfentrazone ethyl 40% 12.5 g / ha. PoE	1571	1592	1582	3673	3718	3696	29.96	29.98	29.97
T_5	Pyrazosulfuron ethyl 10% 20 g/ha (PE) *fb* Chlorimuron ethyl 10% + Metsulfuron methyl 10% 4 g/ha (PoE)	2022	2065	2044	4037	4108	4073	33.37	33.45	33.41
T_6	Pyrazosulfuron ethyl 10% 20 g/ha (PE) *fb* Metsulfuron methyl 20% 4 g/ha (PoE)	1846	1875	1860	3968	4022	3995	31.75	31.80	31.77
T_7	Pyrazosulfuron ethyl 10% 20 g/ha (PE) *fb* Carfentrazone 40% 12.5 g / ha. (PoE)	1662	1688	1675	3873	3921	3897	30.02	30.09	30.06
T_8	Hand weeding twice 20 and 40 DAS	2003	2033	2018	4000	4063	4032	33.36	33.35	33.36
T_9	Green manuring up to 40 DAS	1557	1575	1566	3376	3413	3394	31.56	31.57	31.56
T_{10}	Control	461	469	465	1102	1110	1106	29.48	29.68	29.58
	SEm±	11.18	11.85	11.52	17.49	17.09	17.29	4.26	5.52	4.26
	CD (P=0.05)	33.21	35.21	34.21	51.97	50.77	51.37	12.67	16.39	12.67

Table 2: Economics of Kodo Millets as Influenced by Different Weed Management Practices

Treatments	Cost of cultivation			Gross Income (Rs.)			Net Income (Rs.)			B:C Ratio		
	2021	2022	Mean	2021	2022	Mean	2021	2022	Mean	2021	2022	Mean
T_1: Pyrazosulfuron ethyl 10% 20 g/ha (PE)	23776	23776	23776	46279	46791	46535	22503	23015	22759	1.95	1.97	1.96
T_2: Chlorimuron ethyl 10% + Metsulfuron methyl 10% 4 g/ha (PoE)	23383	23383	23383	49524	50244	49884	26141	26861	26501	2.12	2.15	2.13
T_3: Metsulfuron methyl 20% 4 g/ha (PoE)	23166	23166	23166	48289	49039	48664	25123	25873	25498	2.08	2.12	2.10
T_4: Carfentrazone ethyl 40% 12.5 g / ha. PoE	23308	23308	23308	47136	47766	47451	23828	24458	24143	2.02	2.05	2.04
T_5: Pyrazosulfuron ethyl 10% 20 g/ha (PE) *fb* Chlorimuron ethyl 10% + Metsulfuron methyl 10% 4 g/ha (PoE)	24953	24953	24953	60663	61457	61060	35710	36998	36354	2.43	2.48	2.46
T_6: Pyrazosulfuron ethyl 10% 20 g/ha (PE) *fb* Metsulfuron methyl 20% 4 g/ha (PoE)	24736	24736	24736	55378	56248	55813	30642	31512	31077	2.24	2.27	2.26
T_7: Pyrazosulfuron ethyl 20 g/ha (PE) *fb* Carfentrazone 40% 12.5 g / ha. (PoE)	24878	24878	24878	49847	50627	50237	24969	25749	25359	2.00	2.04	2.02
T_8: Hand weeding twice 20 and 40 DAS	34206	34206	34206	60077	60999	60538	25871	26793	26332	1.76	1.78	1.77
T_9: Green manuring up to 40 DAS	39006	39006	39006	46695	47235	46965	7689	8229	7959	1.20	1.21	1.20
T_{10}: Control	22206	22206	22206	13816	14056	13936	-8390	-8150	-8270	0.62	0.63	0.63

Conclusion

Pyrazosulfuron ethyl 10% 20 g/ha (PE) *fb* Chlorimuron ethyl 10% + Metsulfuron methyl 10% 4 g/ha (PoE) recorded significantly highest seed yield, straw yield, harvest index (%) (Mean *viz.*, 2044 and 4073 kg ha^{-1} and 33.41), gross return (Mean *viz.*, 61060Rsha^{-1}), net return (Mean *viz.*, 36354Rs ha^{-1}) and B: C ratio (Mean *viz.*, 2:46) in kodo mean basis.

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