



Impact of diverse weed management practices on direct seeded finger millet (*Eleusine coracana*)

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ABSTRACT

A Field experiment was carried out during two consecutive years (2016-17) at Agricultural Research Station, Vizianagaram, Andhra Pradesh to find out the best weed management practice for profitable production of direct-seeded finger millet (*Eleusine coracana* L.) under rainfed condition. Two intercultural operations (IC) with hand weeding at 20 and 40 DAS was found effective in reducing weed density and dry weight up to 50 DAS, increasing yield attributes and economic yield. Among the herbicidal treatments, pre-emergence application of isoproturon at 0.50 kg a.i./ha was found superior to reduce the weed density up to 25 DAS. However, application of pre-emergence herbicide alone is not sufficient for effective weed control throughout the critical period of crop-weed competition. Integration of one IC at 30 DAS in addition to pre-emergence application of isoproturon at 0.50 kg a.i./ha was identified as the best weed management practice as it attained minimum weed index (6.4%) and maximum B:C ratio (1.88), weed control efficiency (WCE) (89.7% and 96.9% at 25 and 50 DAS, respectively), herbicide efficiency index (92.5%), growth and yield attributes, grain yield (2230 kg/ha) and straw yield (6512 kg/ha). However, it remained statistically on par with bensulfuron methyl + pretilachlor 0.198 kg a.i. /ha as PE + IC at 30 DAS.

Key words: Direct seeded finger millet, Intercultivation, Pre-emergence herbicides, Weed management

Finger millet is a staple food to the millions of the populace in the arid and semiarid regions of the world. Finger millet secures sixth position in India among major cereal grains (Devi *et al.* 2014) with 11.38 lakh ha area, 18.22 lakh tons production and 1601 kg/ha productivity (GOI 2015). In India its area is mainly concentrated in southern states particularly in Karnataka, Tamil Nadu, Andhra Pradesh and Kerala. It is rich in calcium (0.34%), dietary fibre (18%), phytates (0.48%), protein (6–13%) minerals (2.5–3.5%), and phenolics (0.3–3%) and other essential amino acids making it a powerhouse of health benefiting nutrients (Chandra *et al.* 2016). Finger millet also known for its climate resilience such as adaptation to wide range of climatic conditions, minimum vulnerability to abiotic and biotic stresses, low input requirement, high water use efficiency, etc. Finger millet seeds can resist storage pests for as long as 10 years, ensuring round the year food supply or even during a crop failure, has earned it the name ‘famine crop’ (Mgonja *et al.* 2007).

Among different production constraints, weed infestation is a major concern. Initial slow growth of the

direct-seeded finger millet favours weed growth, causes more competition for growth resources, resulting in yield loss of 21-68% (Asargew and Shibabawu 2014). Manual weeding is costly and time consuming. Limited availability of herbicides for broad-spectrum weed control in finger millet throughout the critical period of crop weed competition necessitates the use of two or more herbicides for attaining optimum control of all kinds of weeds. This leads to increased cost of cultivation. Furthermore, continuous over reliance on herbicides will adversely affect the human health, non-target organisms and the environment. Therefore, there is a need to integrate the chemical and manual weed control methods in a best possible way in order to achieve the maximum weed control in a profitable way. Hence, the present experiment was conducted to draw the best weed management approach for increasing the productivity and profitability of direct sown finger millet.

MATERIALS AND METHODS

Field experiments were conducted during two consecutive rainy (*kharif*) seasons of 2016-17 at Agricultural Research Station, Vizianagaram, Andhra Pradesh situated at latitude of 18.07° N and longitude of 83.26° E, altitude of 58.22 m MSL. Average amount of rainfall received during the period of investigation was 727.2 mm during 2016 and

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648.6 mm during 2017. Maximum temperature ranges from 28.0-31.2°C and minimum temperature ranges from 22.2-29.3°C. Maximum relative humidity ranges from 77.6-89.9% and minimum relative humidity ranges from 48.3-7.0%. The soil of the experimental site was deep red loamy belongs to the order typic Haplustalfs. The soil was low in available nitrogen (187.0 kg/ha), high in available phosphorous (67.0 kg/ha) and medium in available potassium (206.0 kg/ha) and organic carbon (0.61%). The experiment was laid out in randomized block design with three replications. Treatments include T₁: Pre-emergence application (PE) of pendimethalin 0.5 kg/ha, T₂: PE of pendimethalin 0.75 kg/ha, T₃: PE of bensulfuron methyl + pretilachlor 0.132 kg a.i./ha, T₄: PE of bensulfuron methyl + pretilachlor 0.198 kg a.i./ha, T₅: PE of isoproturon 0.5 kg/ha, T₆: pendimethalin 0.5 kg/ha as PE + one inter cultivation (IC) at 30 DAS, T₇: pendimethalin 0.75 kg/ha as PE + IC at 30 DAS, T₈: bensulfuron methyl + pretilachlor 0.132 kg a.i./ha as PE + IC at 30 DAS, T₉: bensulfuron methyl + pretilachlor 0.198 kg a.i./ha as PE + IC at 30 DAS, T₁₀: isoproturon 0.5 kg/ha as PE + IC at 30 DAS, T₁₁: Weed free (Two IC with hand weeding at 20 and 40 DAS) and T₁₂: Unweeded check (control). Sri Chaitanya (VR-847) variety of finger millet was sown on July 12 and July 19, respectively during 2016 and 2017 with a spacing of 30 cm × 10 cm. Recommended dose of NPK fertilizers (60-40-30 kg/ha) were applied. Total quantity of P and K fertilizers were applied as basal at the time of last ploughing and N fertilizer was applied in two split doses at basal and at tillering stages. All the three pre-emergence herbicides at their respective dosages were applied on the same day of sowing after making the spray volume of 500 l/ha. Inter cultivation was done in respective treatments. Nearly 25-30% of the plant population of finger millet was not germinated in the Pendimethalin applied treatments. However, those gaps were filled during thinning and gap filling operation done at 14 DAS. Weed density was recorded at 25 DAS and 50 DAS by using a quadrat of 100 cm × 100 cm (1 m²) size from the centre of the plot. Total weeds inside the quadrat were counted species wise and cut close to the transition of root and shoot in each plot and collected for dry matter accumulation (biomass). The samples were first dried in sun and then kept in oven at 70 ± 2°C. The dried samples were weighed and expressed as biomass (g/m²).

All the crop management practices were followed and the crop was harvested on November 7 and November 13 respectively during 2016-17. Plant height and effective tillers/plant were measured randomly from five plants in each plot. Earhead length was measured from the neck to the tip of the panicle and average earhead length was computed. Similarly, number of fingers was counted randomly from five earheads and average number of fingers per panicle was computed. The 1000-filled grains, taken from sampled earheads, were first counted and then weighed to compute the 1000-grain weight. After harvesting, threshing, cleaning and drying the grain yield was recorded. Cost of cultivation, gross returns, net monetary returns and benefit cost ratio

were computed based on the prevailing market prices of the inputs, grain yield and straw yield during the respective crop season. Square root transformation was done for weed density and weed dry weight as:

$$\sqrt{x+0.5}$$

Weed control efficiency (WCE), weed index (WI) and herbicide efficiency index (HEI) were calculated by using the formulae as suggested by Mani *et al.* (1973), Gill and Vijayakumar (1969) and Krishnamurthy *et al.* (1995), respectively.

RESULTS AND DISCUSSION

Effect on weed: In the experimental field, sedge population was dominant followed by broadleaved weeds and grasses at 25 DAS (Table 1). Three types of weed population were significantly low in weed free plot and significantly high in unweeded check. Among herbicidal treatments, pre-emergence application of Isoproturon @ 0.5 kg a.i./ha has significantly reduced grasses, sedges and broad leaved weeds. It was closely followed by pre-emergence application of Bensulfuron methyl + Pretilachlor @ 0.198 kg a.i./ha. Vinothini and Murali Arthanari (2017) also reported lowest weed density and dry weight with PE of Isoproturon 750 g/ha fb one hand weeding in kodo millet. At 50 DAS, T₆ to T₁₀ treatments have significantly reduced total weed density compared to T₁ to T₅ treatments. This is mainly because of integration of one inter cultivation at 30 DAS in addition to pre-emergence herbicide. Isoproturon @ 0.5 kg a.i./ha+IC at 30 DAS and bensulfuron methyl + pretilachlor @ 0.198 kg a.i./ha+IC at 30 DAS have shown less total weed population compared to other herbicidal treatments. At 25 DAS, weed dry weight was significantly high in unweeded check and it was significantly low in weed free treatment. Among herbicidal treatments, pre-emergence application of Isoproturon @ 0.5 kg a.i./ha (T₅, T₁₀) has resulted lowest weed dry weight and was on par with weed free treatment. At 50 DAS, weed dry weight in T₆, T₇, T₈, T₉, T₁₀ treatments reduced significantly to an extent of 84%, 87%, 88%, 90%, 90% respectively compared to their respective pre emergence herbicide applied treatments T₁, T₂, T₃, T₄, T₅ (Table 1). This clearly indicated that, pre-emergence application of herbicide alone is not sufficient for effective weed control throughout the critical period of crop weed competition in finger millet. Inclusion of one inter cultivation at 30 DAS in addition to pre-emergence herbicide application has significantly reduced weed dry weight which in turn helps in improved crop performance.

Weed growth rate was maximum in unweeded check (8.08 g/m²/day) between 0-25 DAS. All weed management practices significantly reduced weed growth rate compared to unweeded check. Weed free treatment showed the lowest weed growth rate followed by isoproturon @ 0.5 kg a.i./ha as PE and bensulfuron methyl + pretilachlor 0.198 kg a.i./ha as PE. Between 25-50 DAS, weed growth rate was maximum in pendimethalin 0.5 kg/ha as PE (7.88 g/m²/day) and unweeded check (7.39 g/m²/day). Application

Table 1 Effect of weed management practices on weed dynamics, weed dry weight, weed control efficiency, weed index and herbicide efficiency index of finger millet (Mean data of 2 years)

Treatment	G (No./m ²)		S (No./m ²)		BLW (No./m ²)		TWD (No./m ²)		TWDW (g/m ²)		WCE (%)		WGR (g/m ² /day)		WI (%)	HEI (%)
	25 DAS	50 DAS	25 DAS	50 DAS	25 DAS	50 DAS	25 DAS	50 DAS	25 DAS	50 DAS	25 DAS	50 DAS	0-25 DAS	25-50 DAS		
T ₁	5.7 (32.7)	6.3 (40.0)	9.9 (98.0)	8.1 (66.0)	7.1 (50.7)	6.1 (37.3)	13.5 (181.3)	12.0 (143.3)	7.8 (61.2)	16.1 (258.2)	69.7 (33.2)	33.2	2.45	7.88	48.0	6.8
T ₂	6.2 (37.7)	5.8 (33.3)	9.8 (96.3)	8.5 (71.3)	7.6 (59.3)	5.9 (35.3)	13.9 (193.3)	11.8 (140.0)	7.5 (55.5)	15.1 (228.9)	72.5 (40.8)	40.8	2.22	6.94	35.7	32.2
T ₃	5.9 (35.3)	5.6 (31.3)	7.0 (50.0)	7.0 (48.7)	6.4 (42.7)	5.9 (34.7)	11.2 (128.0)	10.7 (114.7)	7.0 (49.4)	13.6 (183.8)	75.5 (52.5)	52.5	1.98	5.38	31.1	41.7
T ₄	4.6 (20.7)	5.2 (27.3)	3.9 (15.3)	6.3 (38.7)	3.9 (14.7)	4.8 (23.3)	7.1 (50.7)	9.5 (89.3)	5.6 (31.3)	12.3 (150.5)	84.5 (61.1)	61.1	1.25	4.77	26.4	51.3
T ₅	2.1 (4.0)	5.0 (26.0)	4.4 (19.3)	6.5 (42.0)	2.3 (6.0)	4.4 (20.0)	5.5 (29.3)	9.3 (88.0)	4.5 (19.5)	10.9 (118.9)	90.3 (69.2)	69.2	0.78	3.98	25.1	53.9
T ₆	5.4 (30.7)	3.3 (10.7)	10.6 (111.3)	5.4 (29.3)	6.0 (36.7)	2.9 (8.7)	13.4 (178.7)	7.0 (48.7)	8.6 (74.7)	6.5 (41.5)	63.0 (89.3)	89.3	2.99	-1.33	15.7	73.4
T ₇	6.6 (42.7)	2.9 (8.0)	9.2 (85.3)	5.6 (30.7)	5.5 (32.0)	3.7 (13.3)	12.7 (160.0)	7.2 (52.0)	7.9 (63.8)	5.4 (29.1)	68.4 (92.5)	92.5	2.55	-1.39	14.0	76.8
T ₈	4.5 (20.7)	3.1 (9.3)	5.6 (31.3)	5.3 (28.0)	5.4 (29.3)	2.6 (8.0)	9.0 (81.3)	6.8 (45.3)	6.7 (45.9)	4.7 (21.9)	77.3 (94.3)	94.3	1.84	-0.96	11.4	82.2
T ₉	3.8 (14.7)	3.3 (10.7)	3.5 (12.0)	4.7 (22.0)	3.2 (10.7)	2.7 (8.7)	6.1 (37.3)	6.5 (41.3)	5.7 (31.6)	4.0 (15.8)	84.3 (95.9)	95.9	1.26	-0.63	7.7	89.8
T ₁₀	1.5 (2.0)	2.8 (7.3)	4.8 (22.7)	4.5 (20.0)	1.5 (2.0)	1.5 (2.0)	5.2 (26.7)	5.5 (29.3)	4.6 (20.7)	3.5 (11.8)	89.7 (96.9)	96.9	0.83	-0.36	6.4	92.5
T ₁₁	2.6 (6.3)	2.2 (4.7)	2.9 (8.0)	2.7 (6.7)	2.0 (3.7)	0.9 (0.3)	4.3 (18.0)	3.5 (11.7)	4.2 (17.5)	3.4 (11.4)	91.3 (97.1)	97.1	0.70	-0.25	-	-
T ₁₂	8.1 (80.0)	11.9 (145.3)	13.4 (185.3)	11.2 (126.7)	11.5 (137.3)	9.1 (85.3)	20.1 (402.7)	18.9 (357.3)	14.2 (202.0)	19.7 (386.6)	-	-	-	-	51.4	-
SEm±	0.87	0.57	0.63	0.50	0.65	0.73	0.48	0.58	0.33	0.35	-	-	-	-	-	-
LSD (P=0.05)	2.56	1.66	1.86	1.46	1.90	2.13	1.41	1.71	0.96	1.03	-	-	-	-	-	-

G: Grasses; S: Sedges; BLW: Broad leaved weeds; TWD: Total weed density; TWDW: Total weed dry weight; WCE: Weed control efficiency; WGR: Weed growth rate; WI: Weed index; HEI: Herbicide efficiency index; DAS: Days after sowing; IC: Inter-cultivation; PE: Pre-emergence

of pre-emergence herbicides alone has shown high weed growth rate but integration of one inter cultivation at 30 DAS along with pre-emergence herbicides has resulted in negative weed growth rate (Table 1).

Effect on crop

Yield attributes and productivity: All the yield attributing characters, grain yield and straw yield were significantly high in weed free treatment (Table 2) due to less weed growth during critical period of crop weed competition. Unweeded check has recorded significantly lowest yield attributing characters like plant height, productive tillers per plant, ear head length, number of fingers per ear head, test weight etc. Grain and straw yields were significantly reduced to an extent of 105.6% and 99% in unweeded check compared to weed free check. Maximum weed density and dry weights at 25 DAS and 50 DAS might be

the reason for severe crop weed competition during early stages. Yield attributing characters, grain yield and straw yield were significantly low in treatments containing pre-emergence herbicides alone (T₁ to T₅) compared to T₆ to T₁₀ treatments. However, inclusion of one inter cultivation at 30 DAS contributed nearly 62%, 34%, 29%, 26%, 25% increment in grain yield and 34%, 22%, 24%, 20%, 18% increment in straw yield respectively in T₆, T₇, T₈, T₉ and T₁₀ treatments compared to their respective pre-emergence herbicide application alone (T₁, T₂, T₃, T₄ and T₅). High initial weed growth due to low weed control efficiency of Pendimethalin 0.5 kg/ha as PE might be the reason for maximum response to inter cultivation. Among different herbicide treatments, isoproturon 0.5 kg/ha as PE + IC at 30 DAS has shown maximum number of productive tillers and test weight and it was on par with bensulfuron methyl + pretilachlor 0.198 kg/ha as PE + IC at 30DAS.

Table 2 Effect of weed management practices on yield attributes, yield and economics of finger millet (Mean data of 2 years)

Treatment	Plant height (cm)	Productive tillers/hill	Ear head length (cm)	No of fingers/panicle	Test weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Cost of cultivation ($\times 10^3$ ₹/ha)	Gross income ($\times 10^3$ ₹/ha)	Net income ($\times 10^3$ ₹/ha)	B:C ratio
T ₁	112.7	2.2	5.3	6.0	3.18	1238	4322	14.90	27.2	12.3	0.83
T ₂	115.5	2.3	5.5	6.5	3.14	1531	4865	15.29	33.7	18.4	1.20
T ₃	118.3	2.4	5.7	6.7	3.25	1641	4932	15.30	36.1	20.8	1.36
T ₄	119.0	2.5	5.8	6.9	3.33	1752	5246	15.90	38.6	22.7	1.42
T ₅	119.7	2.7	6.0	7.2	3.48	1783	5514	15.06	39.2	24.2	1.60
T ₆	122.1	2.8	6.2	7.3	3.43	2008	5792	16.90	44.2	27.3	1.61
T ₇	123.0	2.8	6.5	7.3	3.43	2048	5937	17.29	45.0	27.8	1.60
T ₈	123.2	3.0	6.7	7.5	3.58	2110	6099	17.30	46.4	29.1	1.68
T ₉	124.9	3.1	7.0	7.8	3.63	2198	6314	17.90	48.4	30.5	1.70
T ₁₀	125.0	3.2	7.2	7.9	3.77	2230	6512	17.06	49.1	32.0	1.88
T ₁₁	130.5	3.4	7.3	8.0	3.92	2381	6815	18.50	52.4	33.9	1.83
T ₁₂	110.5	2.2	5.4	5.9	3.11	1158	3421	13.50	25.5	12.0	0.89
SEm±	1.25	0.06	0.04	0.02	0.11	83	101	-	3.37	3.37	0.21
LSD(P=0.05)	3.83	0.18	0.12	0.07	0.32	135	306	-	9.87	9.87	0.61

Similarly, ear head length and number of fingers/ear head were significantly high in isoproturon 0.5 kg /ha as PE + IC at 30 DAS and it were closely followed by bensulfuron methyl + pretilachlor 0.198 kg /ha as PE + IC at 30 DAS. Grain and straw yields were significantly high in isoproturon 0.5 kg/ha as PE + IC at 30 DAS and it was on par with bensulfuron methyl + pretilachlor 0.198 kg/ha as PE + IC at 30 DAS (Table 2). High weed control efficiency of isoproturon 0.5 kg /ha as PE + IC at 30 DAS (89.7% and 96.9% at 25 DAS and 50 DAS respectively) and maximum yield attributing characters might be the reason for high grain and straw yield of finger millet. Similar results with PE of isoproturon were also reported by Ashok (2003) and Sangeeta (2016) in drill sown and direct sown finger millet respectively.

Profitability: Cost of cultivation was maximum in weed free plot compared to other treatments as it involves more number of human labour. Among different herbicidal treatments, bensulfuron methyl + pretilachlor 0.198 kg /ha as PE + IC at 30 DAS showed maximum cost of cultivation and it was closely followed by bensulfuron methyl + pretilachlor 0.132 kg /ha as PE + IC at 30 DAS. Highest gross and net returns were registered in weed free plot and lowest gross and net returns were registered in unweeded check. T₆, T₇, T₈, T₉, T₁₀ treatments have recorded 39%, 25%, 22%, 20%, 20% additional gross returns and 55%, 34%, 29%, 26%, 24% additional net returns respectively compared to their respective pre-emergence herbicide application alone (T₁, T₂, T₃, T₄, T₅). Benefit cost ratio was maximum in isoproturon 0.5 kg/ha as PE + IC at 30 DAS and it was closely followed by weed free treatment (Table 2). This result is in conformity with results obtained by Pradhan *et al.* (2012) in finger millet. Kujur *et al.* (2018) was also reported highest B:C ratio with isoproturon among herbicidal treatments in direct sown finger millet.

Weed control efficiencies: Weed free plot has recorded maximum weed control efficiency at 25 and 50 DAS. Among different pre-emergence herbicides, weed control efficiency of isoproturon @ 0.5 kg a.i./ha was significantly high at 25 DAS and it was on par with bensulfuron methyl + pretilachlor 0.198 kg a.i./ha (Table 1). Banu *et al.* (2016) also reported similar results in transplanted finger millet. However, at 50 DAS, weed control efficiency of pre-emergence herbicides alone has decreased significantly and at the same time, inclusion of inter cultivation at 30 DAS in addition to pre-emergence herbicides has significantly increased weed control efficiency. Pradhan *et al.* (2010) also reported increased weed control efficiency with inclusion of inter cultivation along with pre-emergence herbicides in finger millet. Weed index was significantly low in isoproturon @ 0.5 kg a.i./ha as PE + IC at 30 DAS (6.4) followed by bensulfuron methyl + pretilachlor 0.198 kg a.i./ha as PE + IC at 30 DAS (7.7). Unweeded check has recorded highest weed index (51.4) followed by PE of pendimethalin 0.5 kg a.i./ha (48.0). Among five herbicidal treatments, herbicide efficiency index was significantly high for isoproturon @ 0.5 kg a.i./ha followed by bensulfuron methyl + pretilachlor 0.198 kg a.i./ha. PE of pendimethalin 0.5 kg a.i./ha has shown lowest herbicides efficiency index (6.8).

It is concluded that, isoproturon 0.5 kg a.i. /ha as PE + IC at 30 DAS or bensulfuron methyl + pretilachlor 0.198 kg a.i. /ha as PE + IC at 30 DAS may be a good alternative to weed free (two IC with hand weeding at 20 and 40 DAS) in reducing cost of cultivation and enhancing productivity in direct seeded finger millet.

REFERENCES

- Asargew F and Shibabawu A. 2014. Appropriate time for weed management for finger millet (*Eleusine coracana* Gaertn).

- Journal of Natural Sciences Research* **4**(16): 42–47.
- Ashok E G, Chandrappa M, Kadalli G G and Kumar K.2003. Integrated weed control in drill-sown rainfed finger millet (*Eleusine coracana*). *Indian Journal of Agronomy* **48**(4): 290–93.
- Banu A, Fathima P S, Denesh G R and Sunil C M.2016. Pre and post emergence herbicides for weed management in finger millet. *Indian Journal of Weed Science* **48**(4): 447–449.
- Chandra D, Chandra S, Pallavi and Sharma A K. 2016. Review of Finger millet (*Eleusine coracana* (L.) Gaertn): A power house of health benefiting nutrients. *Food Science and Human Wellness* **5**: 149–55.
- Devi P B, Vijayabharathi R, Sathyabama S, Malleshi N G and Priyadarisini V B. 2014. Health benefits of finger millet (*Eleusine coracana* L.) polyphenols and dietary fiber: A review. *Journal of Food Science and Technology* **51**: 1021–40.
- Gill G S and Vijayakumar.1969. “Weed index” A new method for reporting weed control trials. *Indian Journal of Agronomy* **16**: 96–98.
- Krishnamurthy K, Rajshekara B G, Raghunatha G, Jagannath M K and Prasad T V R .1995. Herbicide efficiency index in sorghum. *Indian Journal of Weed Science* **7**(2): 75–79.
- Kujur S, Singh V K, Gupta, D K, Tandon A, Ekka V and Agrawal H P. 2018. Influence of weed management practices on weeds, yield and economics of finger millet (*Eleusine coracana* L. Gaertn). *International Journal of Bio-resource and Stress Management* **9**(2): 209–13.
- Mani V S, Malla M L, Gautam, K C and Bhagwandas.1973. Weed killing chemicals in potato cultivation. *Indian Farming* VXXII: 17–18.
- Mgonja M A, Lenne J M, Manyasa E and Sreenivasaprasad S. 2007. “Finger millet blast management in East Africa. Creating opportunities for improving production and utilization of finger millet,” in *Proceedings of the First International Finger Millet Stakeholder Workshop, Projects R8030 & R8445 UK Department for International Development—Crop Protection Programme, Patancheru: International Crops Research Institute for the Semi-Arid Tropics*. pp 1-196.
- Pradhan A, Rajput A S and Thakur A. 2010. Effect of weed management on growth and yield of finger millet. *Indian Journal of Weed Science* **42**(1,2): 53–56.
- Pradhan A, Rajput A S and Thakur A. 2012. Effect of weed management practices on finger millet under rainfed conditions. *Indian Journal of Weed Science* **44**(2): 115–17.
- Sangeeta K. 2016. Weed management in fingermillet (*Eleusine coracana* L. Gaertn). Thesis Submitted to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, pp 1–135.
- Vinothini G and MuraliArthanari P. 2017. Pre-emergence herbicide application and hand weeding for effective weed management in irrigated kodo millet (*Paspalum scrobiculatum* L.). *International Journal of Chemical Studies* **5**(3): 366–69.
- Wang J, Vanga S K, Saxena R, Orsat V and Raghavan V. 2018. Effect of climate change on the yield of cereal crops: A review. *Climate* **6**: 41.