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Weed dynamics and yield of transplanted finger millet (*Eleusine coracana* L. Gaertn) as influenced by different weed management practices under lateritic soil of Konkan

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Abstract
The field experiment was conducted during *kharif* season of 2017 to investigate the, “Integrated weed management in *kharif* finger millet (*Eleusine coracana* L. Gaertn) under lateritic soil of Konkan” at Agronomy Farm, College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.). The soil of experimental plot was sandy clay loam in texture, acidic in pH and medium in organic carbon content. It was low in available nitrogen, medium in available phosphorus and available potassium. The soil was leveled, well drained and uniform in depth. The treatments comprised of oxyfluorfen (PE) (T_1), oxadiargyl (PE) (T_2), oxyfluorfen (PE) *fb* HW at 30 DAT (T_3), oxadiargyl (PE) *fb* HW at 30 DAT (T_4), oxyfluorfen (PE) *fb* bispyribac sodium (POE) (T_5), oxadiargyl (PE) *fb* bispyribac sodium (POE) (T_6), oxyfluorfen (PE) *fb* metasulfuron methyl + chlorimuron-ethyl (POE) (T_7), oxadiargyl (PE) *fb* metsulfuron-methyl+ chlorimuron-ethyl (POE) at 25 DAT (T_8), Weed free check (T_9), unweeded check (T_{10}). During the course of present investigation, periodical growth observations, yield contributing characters and yield were recorded to evaluate the treatment effects. Weed intensity, weed control efficiency worked out. Results revealed that among all the treatments, treatment weed free check and among weedicide treatments, treatment oxyfluorfen (PE) @ 0.1 kg a.i. ha^{-1} *fb* HW at 30 DAT produced higher growth and yield attributes as compared to rest of the treatments under study.

Keywords: Finger millet, weed management, herbicide, weed density, WCE, growth and yield

Introduction
Finger millet (*Eleusine coracana* L. Gaertn) is annual crop which belongs to the poaceae family, popularly known as Ragi, Rajika in Sanskrit and Nachani or Nagli especially in Konkan region of Maharashtra. It is an important food grain crop of semi-arid tropics particularly of India and East Africa. It is an important small millet crop in India ranking third among millets with respect to area, production and has the pride of place in having the highest productivity among the millets (Seetharam and Krishne Gowda, 2007) [22]. In many hilly regions of the country finger millet is used as a staple food. It is grown both for grain and fodder purposes and is cultivated up to an altitude of 3000 metres above MSL. The crop is well adapted to very poor and marginal uplands where other crops cannot be grown successfully (Anonymous, 2013) [1].

In India, it is an extensively grown crop over an area of 1.26 M ha with a production of 1.89 M t and a productivity of 1480 kg ha^{-1}. (Anonymous, 2013) [2]. In Maharashtra, finger millet occupies an area of about 0.93 M ha with an annual grain production of 11.10 M tons with productivity 1198 kg ha^{-1}. (Anonymous, 2017) [3]. It is mainly cultivated in Thane, Raigad, Ratnagiri, Sindhudhurg, Dhule, Jalgaon, Nashik, Pune, Satara and Kolhapur districts of Maharashtra. In Konkan region of Mahrashtra, finger millet plays an important role in agriculture with an area of 0.31 M ha with an annual production 0.42 M tons with productivity 1354 kg ha^{-1} (Anonymous, 2017) [3].

In India finger millet is staple food grain for majority of the population as it is economical and very nutritious. It contains dietary fiber protects against hyperglycemia, phytates against oxidation stress by chelating iron and some phenolics and tannins act as antioxidants (Antony, 1998) [4]. Finger millet grains are used in many food preparations like cakes, porridge and sweetmeat in south India. Malted germinating grains are use as nourishment to infants and pregnant women. The finger millet flour is consumed by mixing with milk, boiled water or yoghurt. It is non-acid forming food and easy to digest. It is considered to be one of the least allergic and most digestible foods (Pragya and Rita Singh, 2012) [15].

Finger millet is a small cereal grain with outstanding properties *viz*., strength of calcium (8.3%, iron (0.017%), dietary fibre and polyphenols (0.3 to 3%). Finger millet is rich in calcium content, about 10 times that of paddy or wheat (Stanly and Shanmugam, 2013) [24]. Besides this, it is a good source of essential amino acids of tryptophan, cystine and methionine and thus considered as a favourite wholesome food for hard toiling class and diabetic patients.

Although manual weeding is effective, it is costly, tedious and time consuming. Due to the morphological similarity, it is often difficult to distinguish some grassy weeds from finger millet at early stages and sometimes deficit or excessive soil moisture may not permit efficient weeding. The scarcity of man power at critical period of weed infestation is an important hurdle for timely weeding in finger millet. Under this perspective, the labour relief is most important since weeding operation itself accounts for 25 per cent of overall production labour requirements (Nyende, 2001) [14].

Relying on herbicides may be the best choice of labour saving technology for timely weed control. However, considerable dearth of information is noticed with feasibility of chemical weed control in finger millet. On the other side, farmers are also looking forward for the selective herbicides applied as pre as well as post-emergence to obtain cost effective management of broad spectrum weeds right from the initial stages compared to hand weeding.

Material and Methods

The experiment on "Integrated weed management in *kharif* finger millet (*Eleusine coracana* L. Gaertn) under lateritic soil of Konkan." was conducted at Agronomy Farm, Department of Agronomy, College of Agriculture, Dapoli during *kharif* season of the year 2017-18. The experimental field was levelled and well drained. The soil of the experimental plot was sandy clay loam in texture, acidic in pH and medium in organic carbon content. It was low in available nitrogen, medium in available phosphorus and available potassium. The total rainfall during crop growing season received in 106 rainy days was 3582.4 mm. The minimum temperature was in the range of 21.9 ^{0}C to 25.2 ^{0}C and maximum temperature was 27.4 ^{0}C to 32.5 ^{0}C during crop growth period. The mean relative humidity ranged from 86 to 98 per cent in morning and 68 to 91 per cent in evening during crop period, respectively. In general, the climatic conditions were congenial and favorable for growth of transplanted finger millet during the experimentation period.

The field experiment was consists of ten treatments replicated thrice in randomized block design. The treatments included oxyfluorfen (PE) (T_1), oxadiargyl (PE) (T_2), oxyfluorfen (PE) *fb* HW at 30 DAT (T_3), oxadiargyl (PE) *fb* HW at 30 DAT (T_4), oxyfluorfen (PE) *fb* bispyribac sodium (POE) (T_5), oxadiargyl (PE) *fb* bispyribac sodium(POE) (T_6), oxyfluorfen (PE) *fb* metasulfuron methyl + chlorimuron-ethyl (POE) (T_7), oxadiargyl (PE) *fb* metsulfuron-methyl+ chlorimuron-ethyl (POE) at 25 DAT (T_8), Weed free check (T_9), unweeded check (T_{10}). The gross plot size was 4.50 m x 4.00 m and net plot size was 4.20 m x 3.60 m, respectively. The transplanting of finger millet variety Dapoli-2 was done on 14th July 2017 by thomba method at a spacing of 20 cm X 15 cm. The recommended dose of fertilizer (RDF) (80:40:00 NPK kg ha^{-1}) was used for all the treatments under study. The cultural practices and plant protection measures recommended for finger millet by Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli were used during experiment irrespective of treatments under study.

Result and Discussion

Effect of weed management practices on weed density

Data with reference to mean weed density (m^{-2}) as influenced by different weed control treatments are presented in (Table 1). Among all the treatments under study, treatment weed free check (T_9) recorded significantly lower weed density at 30 and 60 DAT, while treatments oxyfluorfen (PE) *fb* HW at 30 DAT (T_3) and oxadiargyl (PE) *fb* HW at 30 DAT (T_4) was also recorded significantly lower weed density at 30 DAT. In case of total weed density at 90 DAT, treatment oxyfluorfen (PE) *fb* metsulfuron-methyl + chlorimuron-ethyl (POE) (T_7) recorded significantly lower total weed density over rest of the treatments and was at with treatment oxyfluorfen (PE) *fb* bispyribac sodium (POE) at 25 DAT (T_5). In case of total weed density at harvest, oxyfluorfen (PE) *fb* metsulfuron-methyl+ chlorimuron-ethyl (POE) (T_7) recorded significantly lower total weed density over rest of the treatments and was at par with treatment oxyfluorfen (PE) *fb* bispyribac sodium (POE) at 25 DAT (T_5). Treatment unweeded check (T_{10}) recorded significantly higher number total weeds at 30, 60, 90 DAT and at harvest, than rest of the treatments. Same results observed by Ramamoorthy (2002) [19], Murthy *et al.* (2012) [11], Ramachandiran and Balasubramanian (2012) [18], Walia *et al.* (2012) [26], Naseeruddin and Subramanyam (2013) [13] and Veeraputhiran and Balasubramanian (2013) [25].

Among weedicide treatments under study, treatments oxyfluorfen (PE) *fb* HW at 30 DAT (T_3) and oxadiargyl (PE) *fb* HW at 30 DAT (T_4) were recorded significantly lower weed density total weeds at 30 DAT. In case of total weed density at 60 DAT, treatment oxyfluorfen (PE) *fb* bispyribac sodium (POE) at 25 DAT (T_5) recorded significantly lower total weed density over rest of the treatments except treatment oxyfluorfen (PE) *fb* metsulfuron-methyl+ chlorimuron-ethyl (POE) (T_7) which was at par with each other. In case of total weed density at 90 DAT and harvest, treatment oxyfluorfen (PE) *fb* metsulfuron-methyl+ chlorimuron-ethyl (POE) (T_7) recorded significantly lower total weed density over rest of the weedicide treatments except treatment oxyfluorfen (PE) *fb* bispyribac sodium (POE) at 25 DAT (T_5) which remained at par with treatment oxyfluorfen (PE) *fb* metsulfuron-methyl+ chlorimuron-ethyl (POE) (T_7). Treatment oxadiargyl (PE) *fb* metsulfuron-methyl+ chlorimuron-ethyl (POE) at 25 DAT (T_8) recorded significantly higher weed density of total weeds at 30 DAT among all the weedicide treatments. Treatment oxadiargyl (PE) (T_2) recorded significantly higher total weed density at 60, 90 DAT and at harvest, over rest of the treatments. Bhargavi *et al*. (2016) [5] reported on his work at 20 DAT the lowest total weed density was observed in the treatments where PE application of oxyfluorfen was done compared to the treatments that received PE application of oxadiargyl. This might to be due to PE application of oxyfluorfen, which inhibits PPG-oxidase in chloroplast and mitochondria there by blocking chlorophyll synthesis leading to excessive formation of singlet oxygen generating protoporphyrin IX, eventually leading to membrane destruction and killing of weeds. These findings are on similar lines with the findings of Ramana *et al*. (2007) [20] and Murthy *et al*. (2012) [11].

Table 1: Mean weed density (m^{-2}) grasses, sedges and BL Was influenced by different weed control treatments at 30, 60, 90 DAT and at harvest.

Treatments	30 DAT	60 DAT	90 DAT	At harvest
T_1	60.67 (7.79)	154.67 (12.43)	55.33 (7.44)	45.67 (6.76)
T_2	173.00 (13.15)	309.33 (17.58)	91.00 (9.53)	76.00 8.71)
T_3	0.00 (0.71)	81.33 (9.02)	48.33 (6.95)	35.00 (5.91)
T_4	0.00 (0.71)	157.33 (12.51)	74.00 (8.56)	55.67 (7.42)
T_5	48.67 (6.96)	56.67 (7.49)	37.67 (6.13)	28.00 (5.28)
T_6	181.67 (13.48)	100.67 (10.03)	59.00 (7.68)	44.33 (6.66)
T_7	59.67 (7.72)	64.67 (8.01)	36.33 (6.03)	25.33 (4.98)
T_8	221.67 (14.88)	104.00 (10.18)	55.67 (7.44)	37.67 (6.13)
T_9	0.00 (0.71)	0.00 (0.71)	64.33 (8.02)	40.00 (6.32)
T_{10}	530.00 (23.02)	558.33 (23.62)	291.67 (17.08)	228.67 (15.12)
S.Em+	0.93 (0.12)	1.62 (0.22)	0.99 (0.16)	1.00 (0.20)
C.D. at 5%	2.57 (0.32)	4.48 (0.60)	2.75 (0.44)	2.77 (0.54)
General mean	127.53 (8.91)	158.70 (11.16)	81.33 (8.49)	61.63 (7.33)

Note: Figures in parenthesis denotes values of square root transformation.

Effect of weed management practices on weed growth and WCE of transplanted finger millet

Data with reference to weed growth (m^{-2}), weed control efficiency (%) and weed index (%) as influenced by different weed control treatments are presented in previous chapter (Table 2).

Among all the treatments under study, treatment weed free check (T_9) recorded significantly lower total dry matter accumulation over rest of the treatments at 60 DAT, while at harvest, treatment oxyfluorfen (PE) *fb* HW at 30 DAT (T_3) recorded significantly lower total weed dry matter at harvest, over rest of the treatments. While at 60 DAT and at harvest, treatment unweeded check (T_{10}) recorded significantly higher dry matter accumulation of total dry matter accumulation over rest of the treatments. Treatment unweeded check (T_{10}) recorded significantly the highest weed growth compared to rest of weed control treatments at 30, 60, 90 DAT and at harvest. This was due to the unrestricted weed growth in the finger millet crop right from transplanting. The same results recorded by the Ram *et al*. (2005) on pearl millet, Rawat *et al.* (2012), Mishra and Dash (2013) [10] on rice, Prithvi *et al.* (2015) [17] and Bhargavi *et al*. (2016) [5] on finger millet.

Among all treatments under study, the higher weed control efficiency was recorded under treatment weed free check (T_9) at 60 DAT, while at harvest, higher weed control efficiency was recorded under treatment oxyfluorfen (PE) *fb* HW at 30 DAT (T_3). The same results recorded by the Ebhad (1998) [6] on finger millet and Sharma *et al.* (1999) [23] on rice crop. While in case of weed index, lower weed index was recorded by treatment weed free check (T_9).

Table 2: Mean weed growth (g m^{-2}), WCE (%) and weed index (%) of grasses, sedges and BLW as influenced by different weed control treatments.

Treatments	Weed dry matter (g m^{-2})		WCE (%)		Weed Index (%)
	60 DAT	At harvest	60 DAT	At harvest	
T_1	895.07 (29.92)	484.10 (22.00)	58.23	62.05	21.11
T_2	1601.73 (40.02)	711.25 (26.67)	25.11	44.19	46.66
T_3	362.44 (19.04)	99.29 (9.94)	83.48	92.19	6.34
T_4	565.67 (23.76)	276.98 (16.64)	73.42	78.29	13.68
T_5	502.93 (22.42)	182.10 (13.48)	77.38	85.72	17.92
T_6	423.52 (20.58)	358.45 (18.93)	80.14	71.86	28.71
T_7	505.66 (22.49)	329.85 (18.16)	76.60	74.12	58.88
T_8	464.23 (21.54)	248.65 (15.76)	79.21	80.49	26.33
T_9	0.00 (0.71)	184.56 (13.58)	100.00	85.53	00
T_{10}	2185.81 (46.75)	1275.23 (35.71)	00	00	66.02
S.Em+	1.12 (0.11)	1.01 (0.13)	-	-	-
C.D. at 5%	3.11 (0.31)	2.81 (0.35)	-	-	
General mean	750.71 (24.72)	415.05 (19.09)	-	-	

Note: Figures in parenthesis denotes values of square root transformation

Effect of weed management practices on yield of transplanted finger millet

Data pertaining to the grain and straw yields (q ha^{-1}) as influenced by different treatments are presented in Table 3 indicated that, treatment weed free check (T_9) recorded significantly higher grain yield over rest of the treatments except treatment oxyfluorfen (PE) *fb* HW at 30 DAT (T_3) which was at par with each other. In case of straw yield treatment weed free check (T_9) recorded significantly higher straw yield which was significantly superior over rest of the treatments. Treatment unweeded check (T_{10}) recorded significantly lower grain yield and straw yield over rest of the treatments. Among the weedicide treatments, treatment oxyfluorfen (PE) *fb* HW at 30 DAT (T_3) recorded significantly higher grain and straw yield over weedicide treatments under study. Treatment oxyfluorfen (PE) *fb* metsulfuron-methyl + chlorimuron-ethyl (POE) (T_7) recorded significantly lower grain yield and treatment oxadiargyl (PE) *fb* metsulfuron-methyl + chlorimuron-ethyl (POE) (T_8) recorded significantly lower straw yield over rest of the weedicide treatments. All the weed control treatments were significantly superior over the weedy check (T_{10}) and oxyfluorfen (PE) *fb* metsulfuron-methyl+ chlorimuron-ethyl (POE) (T_7) in case of grain yield. This was due to high weed density and biomass. Similar results were obtained by Jayakumar *et al.* (1991) [7], Sagvekar (1991), Singh and Arya (1995), Ravishankara *et al.* (2004) [21] on finger millet, Kumara *et al*. (2007) [9], and Prithvi *et al*. (2015) [17] on finger millet, while Prajapati *et al*. (2007) [16] on Kodo millet.

Table 3: Grain yield, straw yield, harvest index (%) and economics as influenced by different weedicide treatments.

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)	Total cost (ha-1)	Gross income (ha-1)	Net income (ha-1)	B:C Ratio
T_1	21.88	100.95	17.80	62392.3	96138.7	33746.33	1.54
T_2	14.98	99.49	13.03	59543.8	73700.1	14156.35	1.23
T_3	26.34	111.20	19.05	69767.0	113130.8	43363.84	1.62
T_4	24.05	103.29	18.90	68455.1	103754.5	35299.37	1.52
T_5	22.99	103.04	18.31	65734.6	100259.2	34524.63	1.52
T_6	19.78	100.70	16.52	64479.5	89302.2	24822.77	1.38
T_7	11.62	98.85	10.40	57301.5	62372.9	5071.46	1.08
T_8	17.64	97.55	15.28	60745.2	81530.3	20785.08	1.34
T_9	28.10	119.11	19.29	80179.6	120044.7	39865.10	1.50
T_{10}	9.58	81.95	10.61	53996.4	51525.9	-2470.51	0.95
S.Em±	0.64	1.00	-	-	-	54.16	0.10
CD at 5%	1.77	2.77	-	-	-	150.11	0.29
General mean	19.70	101.61	-	-	-	24916.44	1.37

Economics of

Economics of the different weed control measures is presented in Table 3 indicated that net profit was significantly higher under treatment oxyfluorfen (PE) *fb* HW at 30 DAT (T3) as compared to the other treatments with higher B: C ratio. This treatment found effective in reducing the weeds and improving the yield. It was followed bytreatments oxyfluorfen (PE) (T1) and oxadiargyl (PE) *fb* HW at 30 DAT (T4). These results are similar to those reported by Kashid *et al.* (2015) [8] on rice and Pradhan *et al*. (2010) [12] on finger millet.

Conclusion

At harvest, treatment oxyfluorfen (PE) *fb* metsulfuron-methyl + chlorimuron-ethyl (POE) (T7) recorded significantly lower total weed density over rest of the treatments except treatment T5 which remained at par with each other. At harvest the higher weed control efficiency was recorded by treatment oxyfluorfen (PE) *fb* HW 30 DAT (T3). Treatment oxyfluorfen (PE) *fb* HW at 30 DAT (T3) was recorded higher net profit as well as B: C ratio as compared to the other treatments and this treatment was found effective in reducing the weeds and increasing the yield.

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