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RESEARCH NOTE

Integrated weed management effect on yield and economics of cowpea

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ABSTRACT

A field experiment was conducted at instructional farm II of College of Agriculture, Padannakkad, Kerala, India during the *Rabi* 2020 to evaluate the efficacy and identify economic weed management treatment for managing weeds in cowpea [*Vigna unguiculata* (L.) Walp.]. The weed parameters were significantly influenced by the weed management practices. The weed density and biomass and higher weed control efficiency during different periods of crop growth were consistently lower with pre-emergence application (PE) of pendimethalin 0.75 kg/ha + mulching 7t/ha which indicated that pre-emergence herbicide application could effectively manage the weeds emerging early in the season and the later emerged weeds could be successfully controlled by mulching. It was as effective as two hand weeding done 15 and 30 days after seeding (DAS). The effective management of weeds by it resulted in higher yield and B:C ratio.

Keywords: Cowpea, Hand weeding, Imazethapyr, Mulching, Pendimethalin

Pulses are the major source of protein in Indian diet, containing significant amount of fibres, vitamins and minerals. India is the largest producer, consumer and importer of pulses in the world with a production of 23.15 mt from an area of 28.34 Mha with a projected production demand of 35 mt by 2030 (GoI 2018). Weed infestation is one of the major factors that is limiting the productivity of pulses. In Kerala, cowpea [*Vigna unguiculata* (L.) Walp.] is the major pulse crop grown. Farmers, especially in Kasaragod district, are constrained to adopt manual method of weed management for pulses owing to the non-availability and high cost of labour engaged in hand weeding. Cowpea is sensitive to weed infestation especially in the initial 5 to 8 weeks during which uncontrolled weeds cause the cowpea yield loss upto 60% depending on the location, season and weed population (Yadav *et al.* 2017). Hand weeding at 20-35 DAS, pre-emergence application of pendimethalin (PE) 1 to 1.5 kg/ha (Yadav *et al.* 2017) and green leaf mulching by Sapkota *et al*. (2015) were found effective to manage weeds in pulses. Integration of different weed management techniques would result in better management of weeds compared to any single management method (Rao and Nagamani, 2010, Pooniya *et al.* 2014). Hence, this study was carried out to the efficacy and economics of integrated weed management (IWM) treatment to manage weeds in cowpea and improve cowpea productivity.

A field study was conducted at Instructional farm II of College of Agriculture, Padannakkad, Kerala Agricultural university located at 12º14’45’’N latitude and 75º 8’6’’E longitude at an elevation of 9 m above mean sea level from December 2020 to March 2021. The soil was red sandy loam in texture with (low in available N, high in available P and medium in available K). The field experiment was laid out in Randomized Block Design (RBD) with eleven treatments and three replications. The treatments combination were: pre-emergence application (PE) of pendimethalin 0.75 kg/ha at 0-3 days after seeding (DAS); pendimethalin 0.75 kg/ha PE at 0-3 DAS + hand weeding at 20-25 DAS; pendimethalin 0.75 kg/ha PE 0-3 DAS + mulching 7t/ha; post-emergence application (PoE) of imazethapyr 75 g/ha at 20 DAS; imazethapyr 75 g/ha PoE at 20 DAS + hand weeding at 35 DAS; imazethapyr 75 g/ha PoE at 20 DAS + mulching 7t/ha; mulching 7t/ha + hand weeding at 20 DAS; hand weeding twice at 15 and 30 DAS; mulching alone 7t/ha; weedy check (control); weed free. Short duration cowpea variety *PGCP 6* sown at a spacing of 30 x 25 cm with a seed rate of 60 kg/ha. Pendimethalin was applied immediately after sowing while imazethapyr was applied at 20 DAS after the establishment of the crop. Herbicides were applied using knapsack sprayer

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using 500 L of water per hectare. Fertilizers were applied uniformly in all the plots as recommended in the KAU package of practices. Observations on weed parameters were recorded at 15, 30, 45 and 60 DAS by placing quadrat randomly in each of the experimental plot. The weed samples were collected for estimating density, dry weight (biomass), weed index and weed control efficiency of weeds, using standard methodology. Biometric observations were recorded at both flowering and harvesting stage. Yield attributes were recorded at the harvesting stage. These data were analysed statistically using the software WASP 2.0 by ICARGOA.

Effect on weeds

The weed flora observed in the experimental plots were identified and classified based on their ontogeny and morphology (**Table 1**). There were 53 weed species found in the experimental field out of which 34 were broad-leaved weeds, 18 grasses and one sedge (*Kyllinga monocephala*) was observed in the experimental site.

Effect on weed density and biomass

Weed density of an area depends on the weed seed bank, tillage, type of weed seeds present *etc*. (Grundy and Jones 2002). Variation in weed density at different time period was observed (**Table 2**) due to the varying time of application of the different weed management practices, alone or in combination. The weedy check recorded a steady increase in weed density which may be attributed to the absorption of water and nutrients efficiently with minimum competition from the crop.

At 15 DAS, weed density and biomass was minimum where pendimethalin 0.75 kg/ha PE + mulching 7 t/ha which was at par with pendimethalin 0.75 kg/ha at PE and pendimethalin 0.75 kg/ha PE + hand weeding at 20 DAS. Similar observations were made by Yadav *et al.* (2017).

At 30 DAS, significantly lowest value for weed density and biomass was recorded with pendimethalin 0.75 kg/ha PE *fb* hand weeding at 20-25 DAS due to combined efficacy of pendimethalin that managed initial flush of weeds and hand weeding which managed late emerged flushes (20 DAS) that resulted in minimized weed density. This was comparable with mulching *fb* hand weeding at 20 DAS; pendimethalin 0.75 kg/ha PE + mulching 7 t/ha. At 45 DAS, imazethapyr 75 g/ha PoE at 20 DAS + hand weeding at 35 DAS recorded lowest weed density and biomass and was on par with that of pendimethalin 0.75 kg/ha PE + mulching 7 t/ha which indicated that pre-emergence herbicide application could effectively manage the weeds emerging early in the season and the later emerged weeds could be successfully controlled by mulching which was equivalent to two hand weeding done 15 and 30 DAS. At 60 DAS, significantly lowest weed density was recorded with hand weeding twice 15 and 30 DAS which was on par with pendimethalin 0.75 kg/ha PE + mulching 7 t/ha.

Pendimethalin PE alone could not control the weeds efficiently at later stages of the crop growth, in spite of causing delay in weed emergence as indicated by the weed density at 15 DAS. There was significant reduction in weed density when pendimethalin was combined with mulching or hand weeding. The weeds emerged later were suppressed by mulching. Hand weeding, mulching and other intercultural operations and their combination with pre- and post-emergent herbicide application at different period of crop duration has resulted in lower weed density and biomass which can also be attributed to the better utilization of resources by cowpea due to effective weed management by those treatments (Kumar 2008).

Table 1. Weed biodiversity associated with the cowpea

	Annuals	Perennials
Grasses	*Dactyloctenium aegyptium, Panicum maximum, Panicum repens, Brachiaria reptans, Digitaria sanguinalis, Ischaemum rugosum, Eragrostis pilosa, Cenchrus carthamus, Leptochloa chinensis, Poa annua* and *Eleusine indica*	*Cynodon dactylon, Axonopus compressus, Desmostachya bipinnata, Dichanthium annulatum, Stenotaphrum secundatum, Agropyron repens* and *Sorghum halepense*
Sedges	*Kyllinga monocephala*	
Broad-leaved weeds	*Commelina benghalensis, Commelina diffusa, Amaranthus viridis, Ageratum conyzoides, Euphorbia hirta, Scoparia dulcis, Achyranthes Aspera, Chenopodium album, Cleome viscosa, Cleome burmannii, Eclipta alba, Ipomoea pes-tigridis, Vernonia cinerea, Phyllanthus niruri, Setaria verticillata, Leucas aspera, Aerva lanata, Alternanthera sessilis, Ludwigia parviflora, Trianthema portulacastrum* and *Emilia sonchifolia*	*Convolvulus arvensis, Oxalis corniculata, Boerhavia diffusa, Tridax procumbens, Sida acuta, Sida rhombifolia, Desmodium triflorum, Hemidesmus indicus, Mimosa pudica, Alternanthera sessilis, Arachis pintoi, Hyptis suaveolens, Physalis minima, Urena lobata* and *Rhynchosia minima*

Weed free maintained throughout the cropping period recorded the lowest weed biomass and highest WCE (100%) throughout the period of study (**Table 3**). At 15 DAS, the WCE recorded with pendimethalin 0.75 kg/ha PE + mulching; pendimethalin 0.75 kg/ha PE + hand weeding at 20-25 DAS and pendimethalin 0.75 kg/ha PE were on par with weed free. At 30 DAS, pendimethalin 0.75 kg/ha PE + hand weeding at 20-25 DAS has recorded significantly highest WCE among all the treatments except weed free, mulching 7t/ha + hand weeding at 20 DAS and pendimethalin 0.75 kg/ha PE + mulching 7t/ha. At 45 DAS, WCE was significantly higher in hand weeding twice at 15 and 30 DAS which was superior to all other treatments except weed free and on par with imazethapyr 75 g/ha PoE *fb* hand weeding at 35 DAS, mulching 7t/ha *fb* hand weeding at 20 DAS and pendimethalin 0.75 kg/ha PE *fb* hand weeding at 20-25 DAS. At harvesting stage (60 DAS), the treatment mulching 7 t/ha *fb* hand weeding at 20 DAS recorded highest value for WCE which was superior to all other treatments except weed free, pendimethalin 0.75 kg/ha PE *fb* mulching 7t/ha, and imazethapyr 75 g/ha PoE *fb* hand weeding at 35 DAS which were on par with each other. Similar observation made by Mathew *et al.* (1995) and Singh and Sekhon (2013).

The weed index values (**Table 3**) were significantly lowest with mulching *fb* hand weeding at 20 DAS except that with weed free check, pendimethalin 0.75 kg/ha PE + mulching 7t/ha. The effect of seed yield and weeds biomass might be the reason behind low WI (Kumar 2008, Idapuganti *et al.* 2005).

Effect on cowpea

The different IWM combinations were effective in suppressing weed growth for about 40 days which resulted in significant enhancement in pod yield which would otherwise have resulted in about 80% yield loss as observed in the weedy check which recorded the lowest value for pod yield. On comparing the effect of weed density and biomass on the cowpea yield it can be inferred that lower weed density and biomass could effectively reduce the competition between crop and weed for resources which has resulted in increased the cowpea yield. Highest seed yield was recorded in weed free, mulching along with pendimethalin PE and mulching along with hand weeding at 20 DAS (**Table 3**). Mulching reduced the weed growth and competition of weeds against crop from sowing to harvesting by providing the environment conductive to crop growth

Table 2. Weed density and biomass in cowpea at successive crop growth stages

Treatment	Weed density (no./m^2)				Weed dry biomass (kg/ha)			
	15 DAS	30 DAS	45 DAS	60 DAS (at harvest)	15 DAS	30 DAS	45 DAS	60 DAS (at harvest)
Pendimethalin 0.75 kg/ha PE	14.7 (3.9)	29.0(5.4)	62.7(7.9)	150.0(12.2)	76.7(2.1)	356.2(4.3)	629.0(5.5)	2109.0(10.6)
Pendimethalin 0.75 kg/ha PE *fb* HW	16.3(4.1)	4.0(2.1)	36.7(6.0)	95.7(9.8)	71.0(2.0)	6.3(0.9)	120.4(2.5)	329.(4.2)
Pendimethalin 0.75 kg/ha PE + mulching	7.0(2.5)	8.7(3.4)	15.3(4.5)	61.3(7.8)	23.9(1.3)	33.4(1.6)	142.1(2.8)	362.2(4.3)
Imazethapyr 75 g/ha PoE	136.0(11.7)	44.3(6.7)	97.7(9.9)	156.7(12.5)	400.4(4.5)	454.5(4.9)	626.5(5.6)	1976.3(10.0)
Imazethapyr 75 g/ha PoE *fb* HW	140.0(11.8)	45.0(6.7)	11.7(3.5)	82.7(9.1)	428.2(4.7)	444.5(5.2)	26.6(1.4)	432.5(4.9)
Imazethapyr 75 g/ha PoE + mulching	22.3(4.7)	29.3(5.4)	38.0(6.2)	78.3(8.8)	180.9(3.1)	223.5(3.7)	222.3(3.5)	738.6(6.1)
Mulching + hand weeding	26.7(5.2)	5.0(2.3)	23.0(4.8)	70.0(8.3)	174.3(3.0)	13.5(1.1)	26.7(1.3)	435.7(4.7)
Hand weeding twice	127.3(11.3)	13.7(3.7)	17.3(4.2)	52.0(7.2)	311.2(4.0)	101.8(2.2)	26.3(1.3)	490.3(5.0)
Mulching alone	25.7(5.1)	45.0(6.7)	80.0(8.9)	138.3(11.8)	214.0(3.3)	382.4(4.4)	936.7(7.0)	2154.4(10.3)
Weedy check	142.3(11.9)	280.7(16.8)	351.3(18.7)	443.3(21.1)	1832.8(9.6)	4158.5(14.1)	4164.3(14.4)	6915.5(18.4)
Weed free	0.0(0.7)	0.0(0.7)	0.0(0.7)	0.0(0.7)	0.0(0.7)	0.0(0.7)	0.0(0.7)	0.0(0.7)
LSD (p=0.05)	0.72	0.75	1.11	1.28	0.52	0.68	0.67	0.81

*Transformed values are given in parentheses; PE: Pre-emergence; PoE: Post-emergence; HW: Hand weeding

Table 3. Weed control efficiency, seed yield and weed index as influenced by the different weed control treatments in cowpea

Treatment	Weed control efficiency (%)				Seed yield (kg/ha)	Weed index (%)
	15 DAS	30 DAS	45 DAS	60 DAS		
Pendimethalin 0.75 kg/ha PE	95.87(9.81)	91.41(9.58)	84.79(9.23)	69.48(8.36)	1028.52(32.07)	59.75(7.76)
Pendimethalin 0.75 kg/ha PE *fb* HW	96.06(9.82)	99.85(10.01)	97.14(9.88)	94.60(9.75)	1219.63(34.91)	52.25(7.26)
Pendimethalin 0.75 kg/ha PE + mulching	98.70(9.96)	99.20(9.98)	96.58(9.85)	94.77(9.76)	2366.14(48.64)	6.19(2.57)
Imazethapyr 75 g/ha PoE	77.86(8.84)	89.07(9.46)	84.91(9.24)	71.41(8.48)	1170.43(34.21)	54.20(7.39)
Imazethapyr 75 g/ha PoE *fb* HW	76.42(8.76)	89.31(9.47)	99.36(9.99)	93.73(9.70)	1200.24(34.64)	53.03(7.31)
Imazethapyr 75 g/ha PoE + mulching	90.12(9.52)	94.63(9.75)	94.67(9.75)	89.32(9.47)	1261.00(35.51)	50.66(7.15)
Mulching + hand weeding	90.49(9.53)	99.67(10.00)	99.35(9.99)	96.64(9.85)	2336.50(48.33)	4.63(2.20)
Hand weeding twice	83.06(9.14)	97.55(9.90)	99.37(9.99)	92.90 (9.66)	1120.26(33.47)	56.46(7.52)
Mulching alone	88.26(9.42)	90.78(9.55)	77.29(8.81)	68.82(8.32)	851.40(29.17)	66.68(8.19)
Weedy check	0.00(0.70)	0.00(0.70)	0.00(0.707)	0.000(0.707)	181.94(13.48)	92.88(9.66)
Weed free	100.00(10.02)	100.00 (10.02)	100.00(10.02)	100.00(10.02)	2697.16(51.93)	0.000(0.707)
LSD (p=0.05)	0.25	0.07	0.15	0.12	0.47	0.32

*Transformed values are given in parentheses; PE: Pre-emergence; PoE: Post-emergence; HW: Hand weeding

Table 4. Economics of weed control treatments in cowpea

Treatment	Economics			
	Cost of cultivation (x10^3 `/ha)	Gross income (x10^3 `/ha)	Net income (x10^3 `/ha)	BCR
Pendimethalin 0.75 kg/ha PE	79.05	87.42	8.37	1.10
Pendimethalin 0.75 kg/ha PE *fb* HW	80.57	103.67	23.10	1.28
Pendimethalin 0.75 kg/ha PE + mulching	82.09	201.12	119.03	2.45
Imazethapyr 75 g/ha PoE	78.31	99.49	21.18	1.27
Imazethapyr 75 g/ha PoE *fb* HW	80.90	102.02	21.12	1.26
Imazethapyr 75 g/ha PoE + mulching	82.42	107.18	24.77	1.30
Mulching + hand weeding	81.00	198.60	11.76	2.45
Hand weeding twice	81.76	95.22	13.46	1.16
Mulching alone	80.24	72.37	-7.87	0.90
Weedy check	77.96	15.46	-62.49	0.20
Weed free	94.68	229.26	134.58	2.42
LSD (0.01)		4.03	1.00	0.05

resulting in higher cowpea yield. Efficient weed control measures help in the growth and development of crop plants by enhancing photosynthetic process thereby decreasing the crop weed competition leading to improved cowpea seed yield (Freitas *et al.* 2009, Mekonnen *et al.* 2017).

Economics

Highest gross returns and net returns were obtained with weed-free, pendimethalin PW with mulching; and mulching + hand weeding (**Table 4**). Highest value for B: C ratio was recorded with mulching + hand weeding at 20 DAS and pendimethalin 0.75 kg/ha PE + mulching 7t/ha which was on par with weed free due to higher gross income with lower cost of cultivation as observed by Sasikala *et al.* (2004). Integration of weed management methods has leads to efficient control of weeds instead of the use of any single method (Yadav *et al.* 2017).

Application of herbicides along with mulching and provision of mulching followed by hand weeding at most critical stage and maintenance of weed free condition is better and most economical method of weed management in cowpea. Integration of different weed management practices that manage weeds both in the initial stages along with the new weed flushes in the later stages have resulted in better weed management during the critical period of crop weed competition. Pendimethalin PE along with mulching and mulching along with hand weeding could effectively keep the field weed free in the critical period of crop weed competition and this was reflected in the yield and yield attributes. Hence, these proven integrated weed management methods can be recommended for higher yield and profit in cowpea.

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