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RESEARCH ARTICLE

Integrated weed management in mesta (*Hibiscus sabdariffa*)

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ABSTRACT

A Field experiment was conducted during *Kharif* 2018, 2019 and 2020 to evaluate chemical, mechanical, cultural practices and their integration for weed management in mesta (*Hibiscus sabdariffa* L.) under AINP on Jute and Allied Fibres, ARS, Amadalavalasa, Andhra Pradesh. The experiment consisted ten treatments with three replications. The pooled analysis indicated high WCE at 15 days after emergence (DAE) (91%) and 35 DAE (98%), fibre yield (2.08 t/ha), net returns (₹ 40131/ha), B:C (2.44) with pre-emergence application (PE) of pretilachlor 900 g/ha within 48 hrs of sowing with sufficient rain or irrigation followed by (*fb*) hand weeding (HW) at 15 days after emergence (DAE). However, the post-emergence application (PoE) of quizalofop-ethyl 60 g/ha + ethoxysulfuron 50 g/ha at 15 DAE *fb* hand weeding at 30 DAE recorded higher WCE at 35 DAE (99.9%), and 45 DAE (84%), weed management index (5.16), herbicide efficiency index (330.3), integrated weed management index (4.66) and on par fibre yield (1.79 t/ha), net returns (₹ 33181/ha) and B:C (2.24) with that of pretilachlor 50 EC 900 g/ha + HW at 15 DAE. Thus, farmers may use pretilachlor 900 g/ha within 48 hrs of sowing with sufficient rain or irrigation *fb* HW at 15 DAE or quizalofop-ethyl 60 g/ha + ethoxysulfuron 50 g/ha PoE at 15 DAE + HW at 30 DAE for effective and economic weed management and obtaining higher mesta fibre yield .

Keywords: Fibre yield, Herbicides, Integrated weed management, Mesta, Nail weeder, Weed indices

INTRODUCTION

Mesta is an important natural and commercial fibre crop next to cotton and jute. India accounts for 46.3% of area and 50.6% of the estimated raw jute (jute and mesta) production of the world. Majority of the manufactured jute goods consumed in India is for packaging agricultural products and for other jute diversified products, *viz*. geotextile, composite, textile, paper and pulp, handicrafts, biofuel, pharmaceutical, nutraceutical benefits. Raw jute is an eco-friendly and safe packaging material as it is biodegradable, natural, annual renewable source. As per the current provisions of the Jute Packaging Material Act, 1987, 100% of food grains and 20% of sugar are to be mandatorily packed in jute bags and there is high demand for jute bags (sacking).

Raw jute occupied an area of 6.63 lakh ha in India during the year 2020-21, with a production of 95.6 lakh bales and yield of 2595 kg/ha and mesta occupies 6.1% and 4.3% of total raw jute area and production, respectively. In India, West Bengal occupies first place in area (78%), production (80%) and yield (2815 kg/ha) of jute and mesta (2406 kg/ha), while Bihar is leading both in area (32.2%) and production (40.6%) of mesta (DE&S, 2022a). The two cultivated species of mesta grown in India for fibre purpose are Roselle (*Hibiscus sabdariffa*) and Kenaf (*Hibiscus cannabinus*). Mesta (Roselle) is largely grown as rainfed crop during *Kharif* season in West Bengal, Bihar, Odisha, Andhra Pradesh, Assam, Meghalaya, Chhattisgarh, Nagaland and Tripura. In Andhra Pradesh, jute and Mesta are mainly grown in Vizianagaram, Srikakulam, Guntur and Prakasam districts. Mesta occupied an area of 1000 ha in Andhra Pradesh with a production 10440 bales and yield of 1880 kg/ha during the year 2020-21 (DE&S, 2022b).

Under rainfed situation, weed infestation is identified as the important production constraint in mesta cultivation. Fibre yield reduction up to 40 to 70% was reported under unweeded situation (Ghorai *et al*. 2013). Weeds compete with mesta for soil moisture, nutrients and light as its growth is slow during initial crop growth period. Critical period of crop-weed competition in jute is during 21 to 45 days after sowing (Kumar *et al.* 2015). Grassy weeds are predominant in jute and mesta fields followed by sedges and broad-leaved weeds (Bhattacharya 2012, Raju and Mitra 2020). Manual weeding twice in the

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early stages of crop growth has been a common weed management practice in mesta. Conventional manual weeding is more expensive due to high manual labour requirement and involves 30-40% of total cultivation cost (Islam 2014). Mechanical weeding and inter cultivation are difficult as the many of the farmers follow broadcasting instead of line sowing. Application of herbicides can create weed free environment in the initial stages of crop growth and increase fibre yield. Combined application of two or more herbicides is being practised for effective and economic management of weeds in fibre crops. Use of broad-spectrum herbicides checks variety of weeds that are not controlled by single application. Keeping this in view, experiment was conducted to evaluate pre, post emergence herbicides, mechanical, cultural practices and their integration for cost effective weed management with increased fibre yield in mesta.

MATERIALS AND METHODS

Field experiments were conducted for three consecutive years during *Kharif* 2018, 2019 and 2020 under rainfed condition at All India Network Project on Jute and Allied Fibres, Agricultural Research Station (ANGRAU), Amadalavalasa in North Coastal zone of Andhra Pradesh. The experimental site is situated at 18.4°N latitude, 83.89°E longitude and altitude of 35 m MSL. Soil type of the experimental site is sandy loam having acidic pH (5.2), normal EC (0.02 dS/m), low in organic carbon (0.25%), available nitrogen (226 kg/ha), available phosphorus (20.6 kg/ha) and available potassium is medium (205 kg/ha).

The present experiment consisted of ten treatments with a plot size of 5.4 x 4.6 m, replicated thrice in a randomized complete block design. Weed management treatments included pre-emergence application (PE) of pretilachlor 900 g/ha within 48 hrs of sowing with sufficient rain or irrigation followed by (*fb*) hand weeding (HW) at 15 days after emergence (DAE), post-emergence application (PoE) of quizalofop-ethyl 38 g/ha at 15 DAE *fb* HW 30 DAE, quizalofop-ethyl 60 g/ha + ethoxysulfuron 100 g/ha PoE at 15 DAE, quizalofop-ethyl 60 g/ha + ethoxysulfuron 50 g/ha PoE at 15 DAE *fb* HW 30 DAE, propaquizafop 90 g/ha PoE at 15 DAE *fb* HW 30 DAE, pendimethalin 525 g/ha PE within 48 hours after sowing with sufficient rain or irrigation *fb* one HW 15 DAE, nail weeder at 5 DAE *fb* quizalofop-ethyl 60 g/ha PoE at 25 DAE, unweeded check, HW twice/mechanical weeding (nail weeder) at 15-20 DAE and 35-40 DAE and weed free check.

Mesta variety '*AMV 5*' at a seed rate of 12.5 kg/ha was sown with a spacing of 30 x 10 cm by hand dibbling. Mesta crop was sown on 14.07.2018, 12.07.2019 and 12.05.2020 and harvested at 50% flowering on 20.11.2018, 19.11.2019 and 05.11.2020, respectively. Mesta was sown utilizing the rainfall received during 2018, 2019 and with pre sowing irrigation during *Kharif* 2020. Rainfall received during Mesta crop growing period was 956 mm, 953 mm and 953 mm and 676 mm in 2018, 2019 and 2020, respectively. Fertilizers at the rate of 60:13:25 kg NPK/ha were applied to all the treatments uniformly. Nitrogen was applied in three equal splits as basal, top dressing at 30 and 45 days after sowing. Battery operated knapsack sprayer fitted with flat fan nozzle was used for herbicide application. Weed flora was recorded in unweeded plot and weed samples were collected, in all treatments at 15, 35 and 45 days after emergence of crop, by randomly placing two quadrats of 50 x 50 cm. The weed samples were first dried in shade followed by oven drying at 70 °C for 12 hours and recorded weed biomass (g/m^2). Plant height, basal diameter and fibre yield of mesta were recorded at the time of harvesting. Weed indices, *viz.* weed control efficiency (WCE), weed index (WI), weed management index (WMI), herbicide efficiency index (HEI) and integrated weed management index (IWMI) were calculated following methodology of Devasenapathy *et al.* (2008). Sucking pest incidence was observed in all the years and controlled by spraying of dimethoate and profenophos 2 ml/l of water. Incidence of foot and stem rot disease was low to moderate during 2018, moderate in 2019 and was controlled by drenching with Metalaxyl 8% + Mancozeb 64% 3 g/l of water, while it was high during 2020. The crop was harvested at 50% flowering, followed by retting in stagnated water in retting tank. Fibre was extracted manually, washed in fresh water, well dried before recording of fibre weight. Economics of the various weed management practises was calculated considering the cost of all cultivation practices, herbicides used and MSP for mesta during respective years.

Data recorded on weed biomass was subjected to square root transformation ($\sqrt{x+0.5}$) before statistical analysis. The replicated data pertaining to transformed weed biomass, plant height, basal diameter and fibre yield of all the three years was statistically analysed as per the procedure suggested by Gomez and Gomez (1984) for combined analysis of randomized complete block design over years and treatment means were compared at LSD p=0.05.

RESULTS AND DISCUSSION

Weed flora

The weed flora in the experimental field comprised of *Echinochloa colona, Echinochloa crus-galli, Digitaria sanguinalis, Cyanotis axillaris, Cynodon dactylon, Panicum repens, Chloris barbata, Cyperus rotundus, Celosia argentea, Eclipta alba, Euphorbia hirta, Commelina benghalensis, Cleome viscosa* and *Vernonia cineraria.*

Weed biomass

Weed biomass was significantly affected by various weed management treatments across three years of study. The combined analysis over years indicated significant reduction in weed biomass in all weed management treatments over unweeded check. The weed biomass recorded at 15,35 and 45 DAE **(Table 1)** was significantly higher during 2020 compared to 2019 and 2018. Among the various weed management treatments, weed free check recorded significantly lower weed biomass as it was maintained without weeds throughout the crop growing period. The pretilachlor 900 g/ha PE and pendimethalin 525 g/ha PE recorded significantly lower weed biomass at 15 DAE as compared to other treatments and both were on par with weed free check. The interaction effect of various weed management treatments over years was significant; weed free check, pretilachlor 900 g/ha and pendimethalin 525 g/ha were on par and recorded significantly lower weed biomass followed by running of nail weeder at 5 DAE during the year 2018 and 2019. Pretilachlor being the pre-emergence to early post-emergence broad spectrum herbicide effectively controlled the annual grasses, sedges and broad-leaved weeds in the initial stages (Raju and Mitra 2020, Dutta and Kheroar 2020).

Post-emergence herbicides and hand weeding imposed at 15 or 30 DAE resulted in significant decrease in weed biomass at 35 DAE in all the weed management treatments. Unweeded check recorded significantly higher weed biomass and all other treatments were on par with each other. Among, herbicide treatments, lower weed biomass was recorded with quizalofop-ethyl 60 g/ha + ethoxysulfuron 50 g/ha PoE at 15 DAE + HW at 30 DAE followed by propaquizafop 90 g/ha at 15 DAE *fb* HW at 30 DAE and quizalofop-ethyl 38 g/ha at 15 DAE *fb* HW at 30 DAE. The interaction effect was also significant over years; weed free check, quizalofop-ethyl 60 g/ha + ethoxysulfuron 50 g/ha PoE at 15 DAE *fb* HW at 30 DAE, propaquizafop 90 g/ha at 15 DAE *fb* HW at 30 DAE were on par and recorded significantly lower weed biomass during all the three years of experimentation, while pretilachlor and pendimethalin were on par during two out of three studied years.

At 45 DAE, next to weed free check, quizalofop-ethyl 60 g/ha + ethoxysulfuron 50 g/ha at 15 DAE *fb* HW at 30 DAE recorded significantly lower weed biomass and was on par with other treatments except quizalofop-ethyl 38 g/ha at 15 DAE *fb* HW at 30 DAE, nail weeder at 5 DAE *fb* quizalofop-ethyl 60 g/ha at 25 DAE and unweeded check. The interaction effect was also significant and quizalofop-ethyl 5 EC 60 g/ha + ethoxysulfuron 50 g/ha PoE at 15 DAE *fb* HW at 30 DAE, quizalofop-ethyl 60 g/ha + ethoxysulfuron 100 g/ha PoE at 15 DAE recorded significantly lower weed biomass and both were on par with weed free check. Dutta and Kheroar 2020 also reported lowest weed biomass with quizalofop-ethyl + ethoxysulfuron *fb* manual weeding in jute. Singh *et al.* 2015 recorded 23-53% lower weed biomass with quizalofop-ethyl *fb* hand weeding than pretilachlor *fb* hand weeding during critical crop weed competition period. Kumar *et al.* 2015 reported ethoxysulfuron as a broad-spectrum herbicide for control of grass, sedge and broad-leaved weeds in jute. Pooled analysis has clearly indicated that pretilachlor PE and pendimethalin PE controlled weed flora of mesta upto 15 DAE, whereas quizalofop-ethyl 5 EC 60 g/ha + ethoxysulfuron 50 g/ha PoE at 15 DAE *fb* HW at 30 DAE was most effective in controlling weeds at 35 and 45 DAE.

Weed indices

Highest WCE was observed in weed free check at 15, 35 and 45 DAE in all the three years of study, whereas unweeded check recorded lowest weed control efficiency (**Table 1**). At 15 DAE, pooled analysis indicated that pendimethalin 525 g/ha PE recorded WCE of 94 while pretilachlor 900 g/ha recorded (91%). Mechanical weeding with nail weeder at 5 DAE controlled 64% of the weeds upto 15 DAE. All weed management practices recorded WCE of 97.3 to 99.9% at 35 DAE. Application of post-emergence herbicides at 15 DAE followed by hand weeding at 15 or 30 DAE as per the treatments resulted in higher WCE. Quizalofop-ethyl 60 g/ha + ethoxysulfuron 50 g/ha PoE at 15 DAE *fb* HW at 30 DAE recorded higher WCE of 83.9% among all weed management practices at 45 DAE followed by pendimethalin 525 g/ha *fb* HW at 15 DAE (81.6%), quizalofop-ethyl 60 g/ha + ethoxysulfuron 100 g/ha PoE at 15 DAE (80.1%), propaquizafop 90 g/ha PoE at 15 DAE *fb* HW at 30 DAE (77.7%) and pretilachlor 900 g/ha PE *fb* HW at 15 DAE (73.7%). Next to weed free check, pretilachlor 900 g/ha PE *fb* HW at 15 DAE recorded lower weed index of 23% followed by hand weeding twice at 15-20 and 35-40 DAE (27.6%) and quizalofop-ethyl 60 g/ha + ethoxysulfuron 50 g/ha PoE at 15 DAE *fb* HW at 30 DAE (31.5%). Raju and Mitra (2020) also reported higher WCE in mesta with pretilachlor 900 g/ha PE *fb* HW at 15 DAE.

Quizalofop-ethyl 60 g/ha + ethoxysulfuron 50 g/ha PoE at 15 DAE *fb* HW at 30 DAE recorded higher WMI (5.16), HEI (330.31) and IWMI (4.66) compared to all other treatments **(Table 1)**. This was followed by propaquizafop 90 g/ha PoE at 15 DAE *fb* HW at 30 DAE, which recorded WMI, HEI, IWMI values of 3.98, 254.5 and 3.48, respectively. A weed management treatment can be considered as ideal, if it records higher values of weed indices like WCE, WMI, HEI and IWMI and lower value of weed index (Awan *et al.* 2015).

Yield attributes and fibre yield

Integrated weed management practices have shown significant effect on plant height, basal diameter and fibre yield of Mesta. Pooled analysis of three years of experimentation (**Table 2**) indicated that, significantly taller plants (332 cm, 24.2 mm) with higher basal diameter were recorded in weed free treatment. Pretilachlor 900 g/ha *fb* HW at 15 DAE (282 cm, 19.9 mm), quizalofop-ethyl 60 g/ha + ethoxysulfuron 50 g/ha PoE at 15 DAE *fb* HW at 30 DAE (287 cm, 18.7 mm), propaquizafop 90 g/ha PoE at 15 DAE *fb* HW at 30 DAE (281 cm, 18.9 mm), quizalofop-ethyl 60 g/ha + ethoxysulfuron 100 g/ha PoE at 15 DAE (271 cm. 17.4 mm), recorded on par plant height and basal diameter as that of hand weeding twice at 15-20 and 35-40 DAE (298 cm, 18.2 mm). The interaction of weed management practices over years was also found to be significant. Taller plants with higher basal diameter were noticed in weed free check followed by pretilachlor 900 g/ha PE *fb* HW at 15 DAE, quizalofop-ethyl 60 g/ha + ethoxysulfuron 50 g/ha PoE at 15 DAE *fb* HW at 30 DAE and propaquizafop 90 g/ha PoE at 15 DAE *fb* HW at 30 DAE.

Fibre yield of mesta was significantly higher and on par during 2018 and 2019 compared to 2020. Highest fibre yield was recorded in weed free check (2.64 t/ha), which was significantly higher than rest of the treatments. Pretilachlor 900 g/ha *fb* HW at 15 DAE (2.08 t/ha), quizalofop-ethyl 60 g/ha + ethoxysulfuron 50 g/ha PoE at 15 DAE *fb* HW at 30 DAE (1.79 t/ha), quizalofop-ethyl 60 g/ha + ethoxysulfuron 100 g/ha PoE at 15 DAE (1.75 t/ha), propaquizafop 90 g/ha at 15 DAE *fb* HW at 30 DAE

Table 1. Weed biomass and other weed indices as influenced by integrated weed management (pooled data of 2018-2020)

Treatment	Weed biomass (g/m^2)			Weed control efficiency (%)			WMI			HEI			IWMI			WI (%)
	15 DAE	35 DAE	45 DAE	15 DAE	35 DAE	45 DAE	15 DAE	35 DAE	45 DAE	15 DAE	35 DAE	45 DAE	15 DAE	35 DAE	45 DAE	
Pretilachlor 900 g/ha (PE) *fb* HW 15 DAE	1.91 (6.0)	1.47 (2.8)	6.25 (50.3)	91.0	98.2	73.7	1.5	1.4	1.8	1.9	10.4	10.2	1.0	0.9	1.3	23.0
Quizalofop-ethyl 38 g/ha (PoE) at 15 DAE *fb* HW 30 DAE	5.63 (31.5)	0.91 (0.4)	7.24 (58.5)	32.2	99.5	65.5	8.4	0.6	0.8	1.0	311.4	1.8	7.9	0.1	0.3	48.7
Quizalofop-ethyl 60 g/ha + ethoxysulfuron 100 g/ha (PoE) at 15 DAE	5.27 (27.8)	1.32 (1.2)	5.30 (46.2)	38.9	98.3	80.1	5.3	1.1	1.3	1.8	65.9	37.0	4.8	0.6	0.8	33.6
Quizalofop-ethyl 60 g/ha + ethoxysulfuron 50 g/ha (PoE) at 15 DAE *fb* HW 30 DAE	5.35 (29.6)	0.74 (0.04)	4.69 (37.5)	33.6	99.9	83.9	13.1	1.1	1.3	2.4	958.3	30.3	12.6	0.6	0.8	31.6
Propaquizafop 90 g/ha (PoE) at 15 DAE *fb* HW 30 DAE	5.63 (31.5)	0.76 (0.07)	5.68 (49.0)	33.6	99.9	77.7	9.6	1.1	1.3	1.5	748.3	13.7	9.1	0.6	0.7	34.8
Pendimethalin 525 g/ha (PE) *fb* HW 15 DAE	1.67 (4.1)	1.67 (4.1)	5.02 (42.2)	93.8	97.3	81.6	0.3	0.3	0.3	1.6	3.9	3.6	-0.2	-0.3	-0.2	58.8
Nail weeder at 5 DAE *fb* quizalofop-ethyl 60 g/ha (PoE) at 25 DAE	4.25 (20.3)	0.97 (0.5)	7.99 (68.3)	64.4	99.2	57.0	1.1	0.7	1.3	3.4	199.1	1.9	0.6	0.3	0.8	43.7
Unweeded check	7.10 (50.6)	9.37 (92.5)	12.14 (155.4)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	66.3
HW twice/nail weeder at 15-20 DAE and 35-40 DAE	6.46 (41.8)	1.34 (1.3)	7.10 (57.5)	17.1	98.3	66.7	10.8	1.3	1.8	1.5	74.2	4.6	10.3	0.8	1.3	27.9
Weed free check	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	100	100	100	2.1	2.1	2.1	-	-	-	1.6	1.6	1.6	0.0
LSD (p=0.05) for Year	0.14	0.06	0.21													
LSD (p=0.05) for Treatment	2.17	1.73	2.85													
LSD (p=0.05) for Year x Treatment	0.43	0.19	0.65													

* Data is subjected to ($\sqrt{x+0.5}$) before statistical analysis and figures in parenthesis were original values; PE – pre-emergence application within 48 hours of sowing with sufficient rain or irrigation; PoE – post-emergence application, *fb* = followed by; DAE - Days after emergence; HW – Hand weeding; WMI – Weed Management Index; HEI- Herbicide Efficiency Index; IWMI – Integrated Weed Management Index; WI – Weed Index

(1.7 t/ha) recorded on par yields with handing twice at 15-20 DAE and 35-40 DAE (1.89 t/ha). Fibre yield of mesta was significantly lower in pendimethalin 525 g/ha *fb* HW 30 DAE (1.04 t/ha) applied plots and lowest fibre yield was recorded in unweeded check (0.85 t/ha). The increase in mesta fibre yield with pretilachlor 900 g/ha PE *fb* HW at 15 DAE, quizalofop-ethyl 60 g/ha + ethoxysulfuron 50 g/ha PoE at 15 DAE *fb* HW at 30 DAE might be due to the less weed infestation during the critical period of crop weed competition, which lead to increase in the plant height, basal diameter and fibre yield of mesta. Dutta and Kheroar (2020) also observed 33% and 136% increase in fibre yield of jute with application of pretilachlor 900 g/ha PE *fb* HW at 35 DAE and quizalofop-ethyl 60 g/ha + ethoxysulfuron 100 g/ha PoE at 15 DAE *fb* HW 35 DAS, respectively over unweeded plots. Similarly, Raju and Mitra (2020) reported taller plants with higher basal diameter and fibre yield with pre-emergence application of pretilachlor 900 g/ha + HW at 15 DAE. Kumar *et al.* 2015, Dutta and Kheroar (2020) also reported ethoxysulfuron as a broad-spectrum herbicide, which effectively controlled grasses, sedges, broad leaf weeds in jute when applied alone in combination.

Fibre yield obtained across all the treatments during the year 2020 was comparatively lower than 2018 and 2019. This is mainly due to the lower rainfall during early and mid-growth stages of the crop sown with pre sowing irrigation. Water deficit due to largely lower rainfall received during May to September 2020, coupled with incidence of foot stem rot twice during the crop growing period might have affected the crop growth and fibre yield. However, the performance of herbicides across years was stable. Less fibre yield with pendimethalin 525 g/ha PE might be due to its detrimental effect on mesta crop, which was clearly indicated by shorter plants with less basal diameter, low fibre yield, higher weed index, low WMI, HEI and negative IWMI compared

Table 2. Effect of integrated weed management on plant height, basal diameter and fibre yield of Mesta

Treatment	Plant height (cm)				Basal diameter (mm)				Fibre yield (t/ha)			
	2018	2019	2020	Pooled	2018	2019	2020	Pooled	2018	2019	2020	Pooled
Pretilachlor 900 g/ha (PE) *fb* HW 15 DAE	306	285	255	282	22.6	21.2	16.0	19.9	2.55	2.50	1.19	2.08
Quizalofop-ethyl 38 g/ha (PoE) at 15 DAE *fb* HW 30 DAE	272	268	253	265	15.4	14.6	15.4	15.1	1.41	1.30	1.21	1.31
Quizalofop-ethyl 60 g/ha + ethoxysulfuron 100 g/ha (PoE) at 15 DAE	287	272	253	271	19.1	18.1	15.2	17.4	1.96	2.06	1.23	1.75
Quizalofop-ethyl 60 g/ha + ethoxysulfuron 50 g/ha (PoE) at 15 DAE *fb* HW 30 DAE	301	282	277	287	20.5	18.9	16.9	18.7	2.07	1.91	1.38	1.79
Propaquizafop 90 g/ha (PoE) at 15 DAE *fb* HW 30 DAE	305	285	253	281	21.9	19.5	15.3	18.9	2.15	1.98	1.10	1.74
Pendimethalin 525 g/ha (PE) *fb* HW 15 DAE	211	234	252	232	13.3	12.3	16.0	13.9	1.14	0.95	1.03	1.04
Nail weeder at 5 DAE *fb* quizalofop-ethyl 60 g/ha (PoE) at 25 DAE	273	260	248	260	12.8	13.6	14.8	13.7	1.75	1.61	1.06	1.48
Unweeded check	276	245	233	251	12.5	12.4	14.4	13.1	0.83	0.93	0.80	0.85
HW twice/nail weeder at 15-20 DAE and 35-40 DAE	310	320	264	298	19.3	19.9	15.4	18.2	2.00	2.35	1.33	1.89
Weed free check	328	332	335	332	24.8	23.8	23.9	24.2	2.80	3.16	1.95	2.64
Mean	287	278	262		18.2	17.4	16.3		1.87	1.87	1.23	
LSD (p=0.05) for Year				8.9				0.7				0.11
LSD (p=0.05) for Treatment				27.6				3.3				0.47
LSD (p=0.05) for Year x Treatment				28.1				2.2				0.35
CV (%)				6.2				7.9				12.8

PE – pre-emergence application within 48 hours of sowing with sufficient rain or irrigation; PoE – post-emergence application, *fb* = followed by; DAE - Days after emergence; HW – Hand weeding

Table 3. Economics of integrated weed management in Mesta (pooled data of 2018, 2019 and 2020)

Treatment	Gross returns (₹/ha)	Cost of cultivation (₹/ha)	Net returns (₹/ha)	B:C
Pretilachlor 900 g/ha (PE) *fb* HW 15 DAE	68018	27887	40131	2.44
Quizalofop-ethyl 38 g/ha (PoE) at 15 DAE *fb* HW 30 DAE	44581	27668	16913	1.61
Quizalofop-ethyl 60 g/ha + ethoxysulfuron 100 g/ha (PoE) at 15 DAE	58296	25225	33071	2.31
Quizalofop-ethyl 60 g/ha + ethoxysulfuron 50 g/ha (PoE) at 15 DAE *fb* HW 30 DAE	59941	26759	33181	2.24
Propaquizafop 90 g/ha (PoE) at 15 DAE *fb* HW 30 DAE	57519	28886	28633	1.99
Pendimethalin 525 g/ha (PE) *fb* HW 15 DAE	35678	21243	14434	1.68
Nail weeder at 5 DAE *fb* quizalofop-ethyl 60 g/ha (PoE) at 25 DAE	49190	26527	22663	1.85
Unweeded check	29172	17185	11987	1.70
HW twice/nail weeder at 15-20 DAE and 35-40 DAE	62924	32835	30089	1.92
Weed free check	88084	43268	44816	2.04

PE – pre-emergence application within 48 hours of sowing with sufficient rain or irrigation; PoE – post-emergence application, *fb* = followed by; DAE - Days after emergence; HW – Hand weeding to all other treatments. The root and shoot of young mesta seedlings might have absorbed pendimethalin which formed a thin layer at soil surface leading to inhibition of cell division and cell elongation, mitosis in growth of shoots and roots.

Economics

Economics of the weed management treatments pooled over three years of experimentation (**Table 3**) indicated thehighest net returns (₹ 44816/ha) with weed free check followed by pretilachlor 900 g/ha PE *fb* HW at 15 DAE (₹ 40131/ha), quizalofop-ethyl 60 g/ha + ethoxysulfuron 50 g/ha PoE at 15 DAE *fb* HW at 30 DAE (₹ 33181/ha). Weed free check which involved more number of weeding operations, recorded the highest cost of cultivation (₹ 43268). Highest B:C was recorded with pretilachlor 900 g/ha PE *fb* HW at 15 DAE (2.44) followed by quizalofop-ethyl 60 g/ha + ethoxysulfuron 100 g/ha PoE at 15 DAE (2.31) and quizalofop-ethyl 60 g/ha + ethoxysulfuron 50 g/ha PoE at 15 DAE *fb* HW at 30 DAE (2.24). Raju and Mitra (2020) recorded the highest net returns and B:C in mesta with pretilachlor 900 g/ha PE *fb* HW at 15 DAE, while Dutta and Kheroar (2020) reported the highest net returns and B:C in jute with application of quizalofop-ethyl 60 g/ha + ethoxysulfuron 100 g/ha PoE at 15 DAE *fb* HW 35 DAS.

Pretilachlor 900 g/ha PE *fb* hand weeding at 15 days after emergence effectively controlled the weeds in mesta upto 35 DAE, recorded lower weed index and higher fibre yield, net returns next to weed free check and higher B:C. Post-emergence application of quizalofop-ethyl 60 g/ha + ethoxysulfuron 50 g/ha at 15 days after emergence *fb* hand weeding at 30 days after emergence has recorded on par plant height, basal diameter and fibre yield with that of pretilachlor 900 g/ha *fb* HW at 15 DAE, higher WCE at 35 and 45 DAE, WMI, HEI, IWMI, net returns and B:C. Hence, farmers may use one of these two methods depending on the weed intensity and prevailing climatic conditions.

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