

Biologically effective dose of sodium acifluorfen + clodinofofop-propargyl applied as post emergent for weed management in greengram

Mudalagiriappa*, KR Shyamasundar, Pratima Ningaraddi Morab and Subhash Sannappanavar

AICRP for Dryland Agriculture, UAS, GKVK, Bengaluru, Karnataka 560065, India

*E mail: mudal68@yahoo.com

Received: 19 February, 2022

Accepted: 15 April, 2022

Handling Editor:

Dr S. S. Rathore, Indian Agricultural Research Institute, New Delhi

ABSTRACT

Field experiments were conducted during Kharif 2015 and Summer 2016 at AICRP for Agro-forestry, University of Agricultural Sciences, GKVK, Bengaluru. The experiments were laid out in RCBD with three replications comprising of seven treatments. Major weed species observed were *Cyperus rotundus*, *Eleusine indica*, *Dactyloctenium aegyptium*, *Borreria articularis*, *Echinochloa colona*, *Commelina benghalensis*, *Euphorbia geniculata*, *Phyllanthus niruri* etc., The results revealed that post emergence application of sodium acifluorfen 16.5% + clodinofofop-propargyl 8% EC @ 206.25 + 100 g a.i., at 22 DAS recorded significantly higher grain yield (1145 kg ha⁻¹) and haulm yield (1650 kg ha⁻¹), followed by sodium acifluorfen 16.5% + clodinofofop-propargyl 8% EC @ 165 + 80 g a.i., (968 kg ha⁻¹ and 1377 kg ha⁻¹, respectively) with 87.92 per cent weed control efficiency when compared to weedy check (460 kg ha⁻¹ and 731 kg ha⁻¹, respectively) with no phytotoxicity effect on succeeding crop (Finger millet)

Key Words: Bio-efficacy, Greengram, Clodinofofop-propargyl, Sodium acifluorfen, Weed index, Weed control efficiency

INTRODUCTION

Pulses are considered most important or integral part of the protein supplement and Indian dietary system. As the recommendation of the Food and Agriculture organization, the per capita requirement of pulses is 80 g per day but current availability is 31.6 g per day. Among the different pulses grown in India, greengram is the third most important pulse crop in terms of area, production and productivity next to the chickpea and pigeonpea. It is third important pulse crop of India grown in nearly 16 per cent of the total pulse area of the country. In India it is grown in about 4.5 m ha with a total production of 2.64 mt with a productivity of 548 kg/hand contributing 10 % to the pulse production. (Anon, 2021). In Karnataka, it is widely grown in Kharif and covers an area of 3.05 lakh ha with a production of 0.92 lakh tonnes and productivity of 243 kg ha⁻¹ (Anon, 2020-21). More than 90 per cent of the growing area is concentrated in the northern parts of the Karnataka. Mung bean an annual, herbaceous, self-pollinated pulse crop that is raised for grain, foodstuff, vegetable, green manure and feed stock. Yield potential of greengram

decreasing every year in India as well in Karnataka, when compared to the world. Its input requirement is very low, and its drought tolerance crop permits it to face up to adverse environmental conditions, permitting its successful growth in rainfed areas.

Production of pulses has remained almost stagnant over the years since green revolution in the country due to various kinds of biotic and abiotic stresses. Weeds are the principal biotic constraint in production of pulses. One of the major reasons for the decreasing yield due to the inadequate weed management practices leads to the decreasing yield trend. It is estimated that out of total annual losses of agricultural produce from various pests, weeds alone account for 37% loss, which is higher than insect-pests or diseases (Kumar et al., 2013a). Uncontrolled weeds may reduce the yield ranges from 50-90 per cent depending on the season and cultivars (Kumar et al., 2006). Therefore, proper weed management may results in higher yield. Weed interference can be effectively controlled in greengram by hand weeding and inter-cultivation, but, timely availability of labour and continuous rainfall may hinder the management

practices, besides it is costly and time consuming. So, to address these problems, chemical control of weeds i.e., application of herbicides to manage weeds during the critical period of crop weed competition is very important. Several pre and post emergent herbicides are now available in the country. It is necessary to test the bio-efficacy of the newly developed herbicide molecules which are effective in control of weed flora at two to three leaf stages of the weeds in greengram. Keeping the above facts in view an investigation was carried out study the bio-efficacy and phyto-toxicity of early post emergent herbicides on growth and yield of greengram.

MATERIALS AND METHODS

Field experiments were conducted during *Kharif* and summer seasons of 2015-16 at the Eastern Dry Zone of Karnataka which is located between 130° 52' 183" N Latitude and 77° 33' 583" Longitude, Gandhi Krishi Vignan Kendra, University of Agricultural Sciences, Bengaluru, Karnataka, India, to determine the effective doses of sodium acifluorfen + clodinafop-propargyl on greengram. Greengram variety (KKM-3) was sown at a spacing of 30 × 10 cm during *Kharif* (rainy season) 2015, the available N, P and K were 253, 32 and 260 kg/ha, respectively at harvest and in summer (2016) same variety of crop was sown soil samples were analysed at harvest available N, P, K were 259, 32.4 and 269 kg/ha, respectively. The recommended dose of NPK 12:35:25 kg/ha application for two seasons as a rainfed crop. Seven treatments were assigned in a randomized complete block design with three replications. The treatments included sodium acifluorfen 16.5% + clodinafop-propargyl 8% EC (123.75 + 60, 165 + 80 and 206.25 + 100 g/ha) as post-emergence (PoE), sodium acifluorfen 20% SL (165 g/ha) as PoE, clodinafop-propargyl 15% WP (80 g/ha)

as PoE, hand weeding (twice) at 20 and 45 days after sowing (DAS), and weedy check (untreated). Herbicides were applied at a spray volume of 500 litres of water/ha at 22 DAS, using a knapsack sprayer fitted with flat fan nozzle. Weed counts were taken in a quadrat of 50 × 50 cm at 20, 45, 65 DAS and harvest, and expressed as weed density (no./m²). Category-wise dry weights (g/m²) of weeds (sedges, grasses and broad-leaved) were also recorded at 20, 45, 65 DAS and at harvest. Data on weed density and weed dry weight were analyzed using square root transformation. Data on seed yield, haulm yield and weed index were recorded at harvest. Herbicide efficiency index (HEI) and Weed control efficiency (WCE) of different treatments were also calculated as per the formula suggested by Krishnamurthy *et al.* (1975) and Walia (2003), respectively.

$$\text{HEI} = \frac{\text{Yield of treated plot} - \text{Yield in Control}}{\text{Yield in Control}}$$

$$\text{WCE} = \frac{\text{Weed dry weight in control} - \text{Weed dry weight in treated}}{\text{Weed dry weight in control}} \times 100$$

After the harvest of the greengram crop, the residual crop Finger millet was grown to know the phytotoxicity effect on succeeding crop.

RESULTS AND DISCUSSION

Weed flora

Variation in the weed flora of greengram fields grown under different situations; vary with the soil, varieties, season and place of growth (Patel *et al.*, 2011 and Chhodavidia *et al.*, 2013). The weeds flora observed during the experimental period comprised of grasses, sedges and broad-leaved weeds. The major weed flora observed during the experimental cropping period among broad-leaved weeds,

Table 1. Effect of Sodium Acifluorfen 16.5% + Clodinafop-Propargyl 8% EC and other weed control treatments on major weed species density (Number m⁻²) in green gram

Treatments	20 Days After Sowing (during <i>Kharif</i> 2015)											
	Sedges		Grasses			Broad leaf weeds					Grand Total	
	Cr	Ei	Da	Ec	Total	Ba	Cv	Pn	Cb	Eg		Total
Sodium acifluorfen + clodinafop-propargyl (123.75 + 60 g/ha)	4.1	15.4	7.0	4.3	26.7	6.8	4.3	1.5	2.3	2.6	17.5	48.3
Sodium acifluorfen + clodinafop-propargyl (165 + 80 g/ha)	6.4	13.5	6.9	3.1	23.5	7.5	4.4	2.2	2.6	2.2	18.8	48.7
Sodium acifluorfen + clodinafop-propargyl (206.25 + 100 g/ha)	5.1	16.8	7.6	3.7	28.1	6.7	4.0	2.4	2.5	2.0	17.6	50.9
Sodium acifluorfen 20% SL (165 g/ha)	5.7	13.6	7.2	2.9	23.7	5.3	3.2	1.1	2.7	2.1	14.4	43.8
Clodinafop-propargyl 15% WP (80 g/ha)	5.5	14.3	8.8	3.2	26.4	6.0	3.8	1.0	2.4	2.2	15.3	47.1
Hand weeding 20 and 45 DAS	7.3	14.3	6.1	3.1	23.5	4.9	4.4	1.8	2.8	2.2	16.1	47.0
weedy check	6.5	13.6	5.8	2.9	22.4	6.5	4.3	2.1	2.5	2.6	18.0	46.8

Table 1a: Effect of Sodium Acifluorfen 16.5% + Clodinafop-Propargyl 8% EC and other weed control treatments on major weed species density (Number m⁻²) in green gram

Treatments	20 Days After Sowing (during Summer -2016)										
	Sedges			Grasses			Broadleaved Grand Total				
	Cr	Ei	Da	Ec	Total	Ba	Cv	Cb	Eg	Total	
Sodium acifluorfen + clodinafop-propargyl (123.75 + 60 g/ha)	3.2	8.7	4.3	2.3	15.3	5.8	5.3	1.3	1.7	14.2	32.7
Sodium acifluorfen + clodinafop-propargyl (165 + 80 g/ha)	4.0	12.7	4.5	2.8	20.0	3.7	3.2	1.8	1.3	10.1	34.1
Sodium acifluorfen + clodinafop-propargyl (206.25 + 100)	3.2	7.3	4.9	3.2	15.4	3.5	4.0	2.0	1.7	11.2	29.8
Sodium acifluorfen 20% SL (165 g/ha)	4.3	7.7	4.6	2.9	15.2	3.2	3.8	2.2	1.5	10.7	30.2
Clodinafop-propargyl 15% WP (80 g/ha)	3.7	6.0	3.5	2.6	12.1	4.5	3.5	2.0	2.0	12.0	27.7
Hand weeding 20 and 45 DAS	5.3	5.0	5.3	2.7	13.0	3.7	4.0	1.8	2.0	11.5	29.8
weedy check	4.3	7.3	3.6	1.5	12.4	5.3	2.5	1.2	1.5	10.5	27.2

Commelina benghalensis, *Euphorbia geniculata*, *Cleome viscosa*, *Phyllanthus niruri*, *Borreria articularis*, among the grassy weeds, *Eleusine indica*, *Echinochloa colona* and *Dactyloctenim aegyptium* and among sedges, *Cyperus rotundus*. The data pertaining to the species wise weed density (number) presented in the Table 1.

Weed density

The data pertaining to the weed density presented in the Table 2. Before imposition of treatments i.e., at 20 DAS, the density of sedges, grasses and broad leaf weeds were dominant. Sodium Acifluorfen 16.5% + Clodinafop-Propargyl 8% EC (206.25+100 g a.i./ha) application at 22 DAS resulted

in lowering weed density (16.5/m²) at 45 DAS, followed by Sodium Acifluorfen 16.5% + Clodinafop-Propargyl 8% EC (165+80 g a.i./ha) and Sodium Acifluorfen 16.5% + Clodinafop-Propargyl 8% EC (123.75+60 g a.i./ha) (20.1 and 24.1/m², respectively). Similar trend of weed density was observed at 65 DAS and at harvest. The lower weed density was due to the combined application of sodium acifluorfen and clodinafop-propargyl, as sodium acifluorfen effectively controlled the broad leaved weeds by inhibiting the enzyme proroporphyrinogen oxidase (PPG) in weed species and clodinafop-propargyl due to its inhibitory action on enzyme Acetyl co-A carboxylase (Accase) which effectively controlled

Table 2. Effect of Sodium Acifluorfen 16.5% + Clodinafop-Propargyl 8% EC and other weed control treatments on weed density at different stages in green gram

Treatments	20 DAS			45 DAS			65 DAS			At harvest		
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean
Sodium acifluorfen + clodinafop-propargyl (123.75 + 60 g/ha)	5.83 (34.1)	6.98 (48.7)	6.43 (41.4)	4.17 (17.4)	4.76 (22.7)	4.91 (24.1)	3.37 (11.4)	3.68 (13.5)	3.53 (12.5)	3.25 (10.6)	3.33 (11.1)	3.29 (10.9)
Sodium acifluorfen + clodinafop-propargyl (165 + 80 g/ha)	5.71 (32.7)	6.95 (48.3)	6.36 (40.5)	4.64 (21.5)	5.17 (26.7)	4.48 (20.1)	3.16 (10.0)	3.79 (14.4)	3.49 (12.2)	3.13 (9.8)	3.29 (10.8)	3.21 (10.3)
Sodium acifluorfen + clodinafop-propargyl (206.25 + 100)	5.45 (29.8)	7.13 (50.9)	6.35 (40.3)	3.81 (14.5)	4.30 (18.5)	4.06 (16.5)	3.11 (9.7)	3.43 (11.8)	3.28 (10.8)	3.03 (9.2)	3.06 (9.4)	3.05 (9.3)
Sodium acifluorfen 20% SL (165 g/ha)	5.49 (30.2)	6.61 (43.8)	6.08 (37.0)	5.78 (33.4)	6.79 (46.1)	6.31 (39.8)	6.17 (38.2)	6.62 (43.8)	6.40 (41.0)	6.50 (42.3)	7.07 (50.0)	6.79 (46.2)
Clodinafop-propargyl 15% WP (80 g/ha)	5.26 (27.7)	6.86 (47.1)	6.12 (37.4)	5.38 (28.9)	6.05 (36.6)	5.73 (32.8)	5.04 (25.4)	5.52 (30.5)	5.29 (28.0)	4.95 (24.5)	5.37 (28.8)	5.16 (26.7)
Hand weeding 20 and 45 DAS	5.46 (29.8)	6.85 (47.0)	6.20 (38.4)	3.45 (11.9)	4.39 (19.3)	3.95 (15.6)	3.09 (9.6)	3.21 (10.3)	3.16 (10.0)	3.39 (11.5)	2.89 (8.3)	3.15 (9.9)
weedy check	5.22 (27.2)	6.84 (46.8)	6.08 (37.0)	6.99 (48.9)	7.94 (63.1)	7.48 (56.0)	7.71 (59.5)	8.46 (71.6)	8.10 (65.6)	8.13 (66.2)	8.92 (79.6)	8.54 (72.9)
SEm ±	0.11	0.10	0.9	0.13	0.21	0.14	0.11	0.11	0.95	0.11	0.12	0.10
CD (P=0.05)	0.33	0.32	0.28	0.38	0.62	0.4	0.33	0.35	0.29	0.32	0.38	0.31

grassy weeds (Rao, 2011) and it might be due to the broad spectrum activity of application of this post emergence herbicide on weed and their greater efficiency to retard cell division of meristems as a result of which weeds died rapidly (Kalpana and Velayuthum, 2004)) resulted in lower weed density.

Weed dry weight

Dry weight of weed flora differed significantly among the different treatments. The data pertaining to the weed dry weight presented in the Table 3. There is no significant difference were noticed 20 DAS w.r.t to the weed dry weight before the imposition of different treatments. Among the different herbicides and their doses significantly reduces the total weed dry weight at 45, 65 and at harvest. Application of sodium acifluorfen 16.5% + clodinafop-propargyl 8% EC at 206.25+100 g a.i., significantly reduces the weed dry weight (2.55 g/m², 1.95 g/m² and 1.81 g/m² at 45, 65 and at harvest, respectively). This was followed by the sodium acifluorfen 16.5% + clodinafop-propargyl 8% EC at 165+80 g a.i., and sodium acifluorfen 16.5% + clodinafop-propargyl 8% EC at 123.75+60 g a.i., The lower weed dry weight attributed to the combination of both herbicides that have longer effect on controlling weed population and brought significant reduction in the weed dry weight as compared to the control. Similar results of reduced weed dry weight reported by Ali *et al.* (2011) and Thakare *et al.* (2015). The dry matter accumulation of weeds is directly proportional to the yield decline of the crop rather than the weeds population by itself.

Table 3. Effect of Sodium Acifluorfen 16.5% + Clodinafop-Propargyl 8% EC and other weed control treatments on weed dry weight (g/m²) at different stages in green gram

Treatments	20 DAS			45 DAS			65 DAS			At harvest		
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean
Sodium acifluorfen + clodinafop -propargyl (123.75 + 60 g/ha)	2.64 (5.97)	3.10 (8.61)	2.88 (7.3)	2.49 (5.19)	2.77 (6.69)	2.63 (5.9)	1.99 (2.97)	2.12 (3.51)	2.06 (3.2)	1.90 (2.62)	1.94 (2.76)	1.92 (2.7)
Sodium acifluorfen + clodinafop-propargyl (165 + 80 g/ha)	2.64 (5.95)	3.09 (8.53)	2.87 (7.2)	2.43 (4.91)	2.73 (6.47)	2.59 (5.7)	1.87 (2.48)	2.17 (3.73)	2.03 (3.1)	1.81 (2.26)	1.92 (2.69)	1.86 (2.5)
Sodium acifluorfen + clodinafop -propargyl (206.25 + 100)	2.52 (5.33)	3.16 (8.98)	2.86 (7.2)	2.46 (5.07)	2.63 (5.92)	2.55 (5.5)	1.89 (2.57)	2.01 (3.05)	1.95 (2.8)	1.80 (2.23)	1.83 (2.34)	1.81 (2.3)
Sodium acifluorfen 20% SL (165 g/ha)	2.52 (5.33)	2.95 (7.73)	2.74 (6.5)	3.28 (9.75)	3.43 (10.77)	3.36 (10.3)	3.74 (12.97)	3.52 (11.37)	3.63 (12.2)	3.92 (14.36)	3.67 (12.45)	3.80 (13.4)
Clodinafop-propargyl 15% WP (80 g/ha)	2.45 (5.01)	3.05 (8.32)	2.77 (6.7)	2.53 (5.41)	3.03 (8.22)	2.80 (6.8)	2.48 (5.17)	2.98 (7.90)	2.74 (6.5)	2.37 (4.62)	2.86 (7.18)	2.63 (5.9)
Hand weeding 20 and 45 DAS	2.50 (5.27)	3.05 (8.29)	2.79 (6.8)	2.01 (3.05)	2.21 (3.9)	2.12 (3.5)	1.91 (2.66)	1.71 (1.92)	1.81 (2.3)	2.07 (3.30)	1.75 (2.08)	1.92 (2.7)
weedy check	2.41 (4.83)	3.04 (8.27)	2.75 (6.6)	3.77 (13.20)	4.08 (15.65)	3.93 (14.4)	4.12 (15.94)	4.42 (18.57)	4.27 (17.3)	4.36 (18.03)	4.56 (19.83)	4.46 (18.9)
SEm ±	-	0.04	0.03	0.17	0.15	0.13	0.25	0.19	0.20	0.16	0.18	0.14
CD (P=0.05)	NS	0.13	NS	0.52	0.46	0.41	0.77	0.59	0.62	0.49	0.54	0.43

Data averaged over three replication; Data analysed using transformation= Square root of (x+1); Data within parentheses are original values

Effect on weed control efficiency (WCE)

Weed control efficiency significantly differed among the different treatments applied with different herbicides and its dosage. The WCE is directly proportional to the crop yield. WCE indicates the magnitude of effective reduction of weed population and their competition by weed control practices over weedy check. This was highly influenced by different weed control treatments. Among the different weed control treatments WCE found higher in the treatment applied with sodium acifluorfen 16.5% + clodinafop-propargyl 8% EC at 206.25+100 g a.i., (87.92%) followed by sodium acifluorfen 16.5% + clodinafop-propargyl 8% EC at 165+80 g a.i., and sodium acifluorfen 16.5% + clodinafop-propargyl 8% EC at 123.75+60 g a.i., (86.95 and 85.78%, respectively) as furnished in Table 4. The significant reduction in the weed dry weight in turns increases the weed control efficiency due to the broad spectrum weed control effect and elimination of competition from weeds during the critical crop weed competition and their greater efficiency to retard cell division of meristems as a result of which weeds died rapidly. These outcomes were in findings with the Gupta *et al.*, 2013.

Effect on weed index

Weed index is the yield reduction due to competition by the weeds and it was higher in unweeded control plot (66.20%). This was due to the lower seed yield associated with the unweeded control treatment throughout the cropping period. The lower weed index was noticed with the post

Table 4. Effect of Sodium Acifluorfen 16.5% + Clodinafop-Propargyl 8% EC and other weed control treatments on seed yield (kg/ha), haulm yield (kg/ha), weed index (%) and weed control efficiency (%) in green gram

Treatments	Seed yield (kg/ha)			Haulm yield (kg/ha)			Weed index (%)			Weed control efficiency (%) at Herbicide efficiency index					
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	harvest			index		
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean
Sodium acifluorfen + clodinafop propargyl (123.75 + 60 g/ha)	760	942	851	1026	1318	1172	39.92	34.40	37.16	85.47	86.08	85.78	7.07	5.23	6.15
Sodium acifluorfen + clodinafop propargyl (165 + 80 g/ha)	863	1073	968	1208	1545	1377	31.78	25.28	28.53	87.47	86.43	86.95	10.38	7.14	8.76
Sodium acifluorfen + clodinafop propargyl (206.25 + 100)	1068	1221	1145	1505	1795	1650	15.57	14.97	15.27	87.63	88.20	87.92	14.94	10.51	12.73
Sodium acifluorfen 20% SL (165 g/ha)	555	725	640	884	1155	1020	56.13	49.51	52.82	20.35	37.22	28.79	0.60	0.53	0.56
Clodinafop-propargyl 15% WP (80 g/ha)	622	683	653	898	1124	1011	50.83	52.44	51.64	74.38	63.79	69.09	2.57	0.70	1.63
Hand weeding 20 and 45 DAS	1265	1436	1351	1808	2058	1933	-	-	-	81.70	89.51	85.61	-	-	-
weedy check	375	545	460	562	900	731	70.35	62.05	66.20	-	-	-	-	-	-
SEm ±	65.85	79.21	62.50	84.60	98.23	88.2	-	-	-	-	-	-	-	-	-
CD (P=0.05)	199.7	237.6	188.9	248.2	294.7	266.2	-	-	-	-	-	-	-	-	-

emergence application of sodium acifluorfen 16.5% + clodinafop-propargyl 8% EC at 206.25+ 100 g a.i., ha⁻¹ (15.27%) followed by sodium acifluorfen 16.5% + clodinafop-propargyl 8% EC at 165+80 g a.i., and sodium acifluorfen 16.5% + clodinafop-propargyl 8% EC at 123.75+60 g a.i., (28.53 and 37.16%, respectively) as presented in Table 4. As the satisfactory control of weeds owing to reduction in the crop weed competition. This helps the crop to utilize all the available sources like light, moisture, nutrients and space resulting in higher yield was recorded and these results were in conformity with Gupta *et al.* (2013).

Herbicide efficiency index

The herbicide efficiency index (HEI) would indicate about the potential of the herbicide for controlling the weeds along with their phyto-toxicity effect on the crop. The HEI was proposed by Krishnamurthy *et al.*, (1975). The herbicide efficiency index of different treatments is given in Table 5. Maximum herbicide efficiency index was observed in the treatment applied with Sodium Acifluorfen 16.5% + Clodinafop-Propargyl 8% EC (206.25 + 100 g a.i./ha) (12.73), followed by Sodium Acifluorfen 16.5% + Clodinafop-Propargyl 8% EC (165 + 80 g a.i./ha) and Sodium Acifluorfen 16.5% + Clodinafop-Propargyl 8% EC (123.75 + 60 g a.i./ha) (8.76 and 6.15, respectively) as presented in Table 4. Higher herbicide efficiency index was observed due to the broad spectrum of weed control measures adopted in green gram which have resulted in a significantly lower weed biomass in this treatment.

Effect on grain and haulm yield

The application of herbicides in the greengram was found significant on the yield of the crop. Post emergence application of sodium acifluorfen 16.5% + clodinafop-propargyl 8% EC at 206.25+100 g a.i., ha⁻¹ sprayed at 22 DAS suppresses the biomass of the weed flora and promotes the higher yield of greengram (1145 kg/ha) and this was followed by sodium acifluorfen 16.5% + clodinafop-propargyl 8% EC at 165+80 g a.i., ha⁻¹ and sodium acifluorfen 16.5% + clodinafop-propargyl 8% EC at 123.75+60 g a.i., ha⁻¹ (968 and 851 kg/ha, respectively) as furnished in Table 4. Higher greengram yield in this treatment may be attributed to the better control of weeds that reduces the crop-weed competition and thereby providing better yield attributes and yield. These results were in lined with the Vivek *et al.*, 2008. A similar improvement in greengram under different weed control treatments was reported by Younesabadi *et al.* (2013). Where, sodium acifluorfen helps in inhibition of enzyme protoporphyrinogen oxidase (PPG or Protox). Leaves of the susceptible plants become chlorotic and then desiccated and necrotic within 1-2 days after spraying and clodinafop-propargyl acts as an acetyl Co-A carboxylase (ACCase) inhibitor, clodinafoppropargyl is absorbed by the leaves and rapidly translocated to the growing points of leaves and stems. It affects the production of fatty acids needed for the plant growth in susceptible grassy weeds and there by reduces weed flora and increases the yield of greengram. The same trend was followed for the production of haulm of the greengram.

Table 5. Effect of different weed management treatments on economics of greengram

Treatments	Cost of cultivation (x10 ³ /ha)		Gross returns (x10 ³ /ha)		Net returns (x10 ³ /ha)		B: C Ratio	
	2015	2016	2015	2016	2015	2016	2015	2016
Sodium acifluorfen + clodinafop-propargyl (123.75 + 60 g/ha)	24.50	24.85	38.00	47.10	13.50	22.25	1.55	1.90
Sodium acifluorfen + clodinafop-propargyl (165 + 80 g/ha)	25.00	25.40	43.15	53.65	18.15	28.25	1.73	2.11
Sodium acifluorfen + clodinafop-propargyl (206.25 + 100)	25.50	25.85	53.40	61.05	27.90	35.20	2.09	2.36
Sodium acifluorfen 20% SL (165 g/ha)	24.50	24.85	27.75	36.25	3.25	11.40	1.13	1.46
Clodinafop-propargyl 15% WP (80 g/ha)	25.50	25.85	31.10	34.15	5.60	8.30	1.22	1.32
Hand weeding 20 and 45 DAS	31.20	31.60	63.25	71.80	32.05	40.20	2.03	2.27
weedy check	20.50	20.80	18.75	27.25	-1.75	6.45	0.91	1.31

Effect on economics

Higher net returns and B:C ration were observed with application of sodium acifluorfen 16.5% + clodinafop-propargyl 8% 80 EC at 206.25 + 100 g/ha (27900/ha and 2.09, respectively) and at 165 + g/ha (18150/ha and 1.73, respectively). However, two rounds of hand weeding recorded higher gross returns (32050/ha) as compared to other treatments. The lower cost of cultivation, gross returns, net returns and B:C ratio were recorded in the weedy check plots (20500/ha, 18750/ha, -1750/ha and 0.91, respectively). The similar results were obtained during 2016 (Table 5). The highest net returns and B:C ratio with application of sodium acifluorfen 16.5% + clodinafop-propargyl 8% 80 EC at 206.25 + 100 g/ha was due to higher pod yield with lesser cost of weeding with herbicide application. Similar results were reported by Mudalagiriappa *et al.* (2021). Even though higher gross returns were recorded in two hand weeding, higher labour wages increased the cost of cultivation and lowered the B:C ratio. Similar findings were reported by Kalhapure *et al.* (2013).

Effect on succeeding crop

Growth and yield of succeeding finger millet was not affected due to imposition of weed management practices in preceding greengram. This was in accordance with Sathya Priya and Chinnusamy (2020). The germination percentage was recorded and other physiological factors like yellowing, stunting, wilting and deformities *i.e.*, epinasty, hyponasty and necrosis etc. were not noticed.

CONCLUSION

Herbicide management is an easy and cost-effective weed control option in greengram because

frequent rainfall often limits timely manual weed management along with the additional burden of rising labour cost. From this study, among the herbicide management, it can be concluded that post-emergent application of Sodium Acifluorfen 16.5% + Clodinafop-Propargyl 8% EC (206.25+100 g a.i./ha) at 22 DAS helps in better control of both grassy and broad-leaved weeds in greengram. As it improved the growth and yield of green gram through better weed control efficiency and it was non phyto-toxic to the crop and also to the germination of the succeeding crop finger millet.

ACKNOWLEDGEMENT

The authors are grateful to the University of Agricultural Sciences (UAS), Bangalore, Karnataka for providing all the guidance and necessary facilities for conducting the research study. They are also thankful to the technical staff who have worked in the field experiments and recorded the observations on different weed parameters.

REFERENCES

- Ali, S., Patel, J. C., Desai, L. J. and Singh, J. 2011. Effect of herbicides on weeds and yield of rainy season greengram (*Vigna radiata* L.). *Legume Research*. **34**(4): 300-303.
- Anonymous. 2019. Annual Reports, Directorate of Statistics and Economics, Government of India.
- Anonymous. 2021. Greengram outlook report- January to May. Agricultural Market Intelligence Centre, ANGRAU, Lam.
- Anonymous. 2021. Kharif pulses prospects. DPD, Bhopal.
- Chhodavadia, S. K., Mathukiya, R. K. And Dobariya,

- V. K. 2013. Pre and post-emergence herbicides for integrated weed management in summer greengram. *Indian Journal of Weed Science*. **45**(2): 137-139.
- Gupta, V., Singh, M., Kumar, A., Sharma, B. C. and Kher, D. 2013. Influence of weed management practices on weed dynamics and yield of urdbean (*Vigna mungo*) under rainfed conditions of Jammu. *Indian Journal of Agronomy*. **58**(2): 220-225.
- Kalhapure, AH, Shete, BT and Bodake PS. 2013. Integration of chemical and cultural methods of weed management in groundnut. *Indian Journal of Weed Science* **45**(2): 116-119.
- Kalpana, R. and A. Velayutham. 2004. Effect of herbicides on weed control and yield of soybean. *Indian Journal of Weed Science*. **36**(1 & 2): 138-140.
- Kumar, A., Malik, Y. P. And Yadav, A. 2006. Weed management in mungbean. *Journal of Research*. **36**(2): 127-129.
- Kumar, N., Hazra, K.K., Singh, M.K., Venkatesh, M.S., Kumar, L., Singh, J. and Nadarajan, N. 2013a. Weed Management Techniques in Pulse Crop, 47 pp. Technical Bulletin 10/2013. Indian Institute of Pulses Research, Kanpur, Uttar Pradesh.
- Krishnamurthy K., Raju B.G., Raghunath G., Jagnath M.K. and Prasad T.V.R. 1975. Herbicide efficiency index in sorghum. *Indian Journal of Weed Science* **7**(2): 75-79.
- Mudalagiriappa, D.C. Hanumanthappa, G.M. Sujith and Subhas Sannappanavar. 2021. Bio-efficacy of ready-mix sodium acifluorfen + clodinafoppropargyl for weed management in groundnut. *Indian Journal of Weed Science* **53**(2)
- Patel, V. M., Patel, V. S. And Thanki, J. D. 2011. Effect of irrigation levels and weed management practices on weed growth and yield of summer blackgram under South Gujarat condition. *Green Farming*. **2**(2): 182-184.
- Rao, A. S. 2011. Evaluation of pyriithobac alone and in combination with grassy herbicides on weed control in cotton. *World Cotton Research Conference on Technologies for prosperity* pp. 406-409.
- SathyaPriya R and Chinnusamy C. 2020. Integrated weed management in altered crop geometry of maize and residue effects on succeeding Bengal gram. *Indian Journal of Weed Science*. **52**(1): 93-98.
- Thakare, S.S., Deshmukh, J. P., Shingrup, P. V., Pawar, P. M. and Ghlop, A. N. 2015. Efficacy of different new herbicide against weed flora in soybean (*Glycine max* L.) *Plant Archives* **15**(1): 217-220.
- Vivek, N. S. Rana, Raghuvir Singh and S. S. Tomar. 2008. Effect of Weed Interference on Weeds and Productivity of Blackgram (*Phaseolus mungo*). *Indian Journal of Weed Science*. **40** (1 & 2): 65-67
- Walia US. 2003. Weed management, pp. 396. Kalyani publishers, Ludhiana.
- Younesabadi, M., Das, T. K. and Sharma, A. R. 2013. Effect of tillage and tank mix application on weed management in soybean (*Glycine max*). *Indian Journal of Agronomy*. **58**(3): 372-378.