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Studies on ecology of *Echinochloa* spp. and effect of herbicide on their distribution pattern in upland paddy under mid-hill condition

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ABSTRACT

A field experiment was conducted during 2010 and 2011, at Kalimpong with the objective of improving the production of rice with sustainable weed management practices. Study revealed that the two species of Echinochloa i.e E colona, and E.crusgalli preferred moist condition and continued to grow under shallow submergence condition of hills. Among all the chemical treatments grassy weed biomass was lowest with the application of Pretilachlor fb by 2,4 DEE (1.0 and 0.5 Kg ha^{-1}, respectively). This treatment was followed by incorporation of Pendimethalin fb 2,4 DEE (1.0 and 0.5 Kg ha^{-1}, respectively). Amongst various chemical treatments, minimum weed biomass was registered with the incorporation of Pretilachlor fb 2,4 DEE (1.0 and 0.50 Kg ha^{-1}, respectively) and was statistically superior to other set of experiment during the first year of at 30 DAT. However in the second year of 30 DAT this treatment was at par with the Pretilachlor (1.0 Kg ha^{-1}) and statistically better than other chemical treatment practices. Amongst various chemical treatments maximum grain yield of 5.13 t ha^{-1} was observed in first year with the application of Pretilachlor fb 2,4 DEE (1 and 0.5 Kg ha^{-1}, respectively) and was at par with the Pretilachlor (1.0 Kg ha^{-1}) (5.7 t ha^{-1}) and hand weeding twice (5.23 t ha^{-1}). However, in second year highest grain yield of 4.93 t ha^{-1} was registered with the application of Pretilachlor fb 2,4 DEE (1 and 0.5 Kg ha^{-1}, respectively), and was at par with the Anilofos + 2,4 DEE (1 + 0.5 Kg ha^{-1}) (4.81 t ha^{-1}) and hand weeding twice (5.0 t ha^{-1}). Straw yield was maximum observed with the hand weeding twice (6.80 t and 6.46 t ha^{-1}), and was at par with the Pretilachlor fb 2,4 DEE (1 and 0.5Kg ha^{-1}, respectively) and Anilofos +2,4 –DEE (1 + 0.5 Kg ha^{-1}) during both the years this was at par with the Pendimethalin (1 Kg ha^{-1}), Pretilachlor fb 2,4 DEE (1 and 0.5Kg ha^{-1} , respectively) and Anilofos +2,4 DEE (1 + 0.5 Kg ha^{-1}).

Key words: *Echinochloa, herbicide, rice, weed, yield*

World's rice demand is projected to increase by 25% from 2001 to 2025 to keep pace with population growth (Renukaswamy *et al*., 2012), and therefore, meeting ever increasing rice demand in a sustainable way with shrinking natural resources is a great challenge. Weed is as old as agriculture, and from the very beginning farmers realized the interference of weed with crop productivity (Ghersa *et al*., 2006), which led to the co-evolution of agroecosystems and weed management (Mukherjee, 2007). Concentrated research efforts are being made by the scientists around the world to adopt, apply and evaluate the methodology for improving rice yield. Understanding and prediction of crop response to environment is the major theme, which may further help to identify improved crop management practices. Most of improved crop management practices in rice is failed due poor care of weed flora present in rice field. Weeds are the greatest yield-limiting constraint to rice. Rice field colonized by terrestrial, semi-aquatic or aquatic weeds depending on the types of rice culture and season. Out of various weed flora which compete with rice crop for nutrients, light and moisture *Echinochloa* is one of the most important weeds of rice. It grows throughout the rice growing seasons and grows widely both in temperate and tropical region, and is abundant in all types of rice culture and causes great yield losses to the crop (Rao *et al*., 2007). An obnoxious weed, *Echinochloa colona* started germinating almost simultaneous with the germination of the rice seeds and *Echinochloa crusgalli* appeared after ten days of

the crop emergence. *Echinochloa* spp. are persistent and highly troublesome in rice because of their similar ecological requirements. At early growth stage, they resemble rice and accumulate considerable amount of added nutrients at the cost of rice (Singh *et al.*, 2003). Rice yield losses from season long competition with different species of barnyard grass might be as high as 80-90 % because of high population of these weeds (Singh *et al.*, 2003). In recent decades, the predominant weed control method in many parts of the world has been the use of effective and reliable chemical herbicide. Presently few herbicide are found to be effective to check the population of *Echinochloa* spp. in plains (Chopra and Chopra, 2003). But yet efficacy of herbicide against this weed in hilly region is not exploited fully because the basic knowledge on the biology and ecology of these weeds is lacking (Zhao *et al*., 2006).

A common knowledge of weed flora, their time of emergence, density and growth duration is essential for formulating sound weed control measures particularly under terraced cultivation.The most problematic barnyard grasses found in rice fields under mid hill condition of eastern Himalaya are *Echinochloa colona* (L.) Link, and *E. crusgalli* L. In Darjeeling hill and it's adjoining part both the species are more predominantly found. Judicious selection of herbicide, correct times of application, proper dose and method of application are important criteria for higher weed control efficiency and crop yield. Proper application of various herbicide is quite limited in farmer field. Keeping these points in mind present investigation was planned to attain adequate information on effective control of Echinochloa spp along with other weeds under hill condition for sustainable rice production under mid hill condition..

MATERIALS AND METHODS

The present study was carried out during wet season 2010 and 2011 at UBKV, Kalimpong ($26^0$59–$27^0$2'N & $88^0$26–$88^0$29'E; 1,249 m asl). The climate of site is sub temperate type and is characterized by mild summer. The soil was sandy loam in texture, high in organic carbon (0.90%), available N (280.54 kgha^{-1}), P_2O_5 (21.6 kg ha^{-1}) and K_2O (198.6 kg ha^{-1}) content with pH 5.3. The total rainfall recorded during crop growth period was 1049.51 and 985.16 mm, minimum temperature ranges from 10.1 to 15.3 and 13.1 to 15.6, maximum temperature 25.2 to 31.2 and 25.3 to 31.1^0 C and maximum and minimum relative humidity 93.19, 64.36 and 91.23, 53.11 %, respectively, during 2010 and 2011, respectively. Two *Echinochloa* spp. were collected from rice fields at maximum tillering stage and the taxonomic features including plant height, appearance , growth habitats and other feature were studied. The field experiment was conducted in randomised block design with three replication, having twelve treatments combinations viz. Pendimethalin (0.5, 0.75 and 1.0 kg a.i ha^{-1}), Pretilachlor 50 EC (0.5, 0.75 and 1.0 kg a.i ha^{-1}), Pendimethalin fb by 2,4 DEE (1.0 and 0.5 kg a.i ha^{-1}), Pretilachlor fb by 2,4DEE (1.0 and 0.5 kg a.i ha^{-1}), anilofos (1.0 kg a.i ha^{-1}) and anilofos +2, 4 DEE (1.0 + 0.5 kg a.i ha^{-1}) along with hand weeding twice (25 and 50 DAT) and weedy check. Twenty five days old seedlings of rice variety Sarju 52 were transplanted on 2nd July and 4th July, 2010 and 2011, respectively. One third of the recommended dose of N (i.e. 40 kg ha^{-1}) and full dose P_2O_5 and K_2O (60 kg ha^{-1} each)were applied before transplanting and remaining two third of (i.e. 80 kg ha^{-1}) of N was top dressed in two equal splits, half at active tillering and half at panicle initiation stages. All the herbicides except 2,4 DEE were sprayed 8 days after transplanting (DAT) using 600 litre water ha^{-1} with the help of knapsack sprayer, fitted with flat fan nozzle. However 2, 4 DEE was applied 25 DAT, to check broad leaf weed population as per thetreatments. Moreover, in the treatment consisting of anilofos +2, 4 DEE (1.0 + 0.50 kg a.i ha^{-1}), 2,4 DEE was tank mixed with anilofos and appliedat 8 DAT. The weed density was recorded by placing a quadrate of 0.25 m^2 three times randomly in all the treatmentsat 30 and 60 DAT. Weeds inside the quadrate were identified, visually, counted and recorded, and weed density m^{-2} was calculated. To record dry weed biomass, in all the treatments a quadrate of 0.25 m^2 was randomly placed 3 times inside all plots and the weeds surrounded by the quadrates were cut through a manual cutter at 30 and 60 DAT, placed separately in marked paper bags, dried in an oven at 72 ± 3^{o}C for 48 hours and weighed to record their dry biomass (g) using an electronic balance and expressed as biomass per m^2 Weed control efficiency (WCE) was calculated at 30 and 60 DAT using the following formula Kabir *et al*., (2008).

$$WCE = \frac{DMC - DMT}{DMC} \times 100$$

where,

DMC = Dry matter production of weeds m^{-2} in unweeded check.

DMT = Dry matter production of weeds m^{-2} in the treatment to be compared.

The weed index was calculated by using the formula of Renukaswamy *et al*. (2012)

$$\text{Weed index} = \frac{X - Y}{X} \times 100$$

where,

X = Grain yield from hand weeding twice.

Y = Grain yield from treatment for which weed index is to be worked out.

RESULTS AND DISCUSSION

Echinochloa spp. preferred moist and humid condition, and continued to grow when submerged at soil depth 2 to 3 mm under terrace cultivation. This corroborate with the finding of Bhagirath *et al*. (2011). *E.crusgalli* attained maximum height (180-200 cm) while *E. colona* was short statured (60 - 70 cm). The culms of *E.colona* were slender, while others had shorter culms. The panicles were small in case of *E.colona* but longer in other species. The arrangement of spikelets on panicle was in four rows in case of *E.colona* but irregular in case of other species. Both *E.colona* and *E. crusgalli* were awanless, however in *E. crusgalli* sometime awns was found with green to purplish in colour. The branches of rachis were closer in case of *E. crusgalli* but wider in *E.colona*. The stigma colour of *E. colona* was some what blackish purple while white or red in rest of the species. *E.crusgalli* was enormous seed producers compared to *E.colona*. The seed of *E.colona* had less dormancy compared to other species had longer dormancy in rice fields. Grain shattering was also very high in *E.colona* compared with others (Table 1). The seedlings of both the species had a tendency of elongation under moderate flooding, whereas they ceased to elongate under long deep water logging in terrace.

All the herbicidal treatments significantly reduced the population of *E.colona* and *E.crusgalli* at 30 and 60 DAT compared to weedy check during both the years (Table 2). Pretilachlor fbby 2,4 DEE (1.0 and 0.5 Kg ha^{-1}) was found to be equally effective to hand weeding in controlling the population of *E.colona* at 30 DAT during the both the years, and was at par with hand weeding twice during both the years. This treatment recorded minimum weed population compared to other treatments. Whereas, at 60 DAT hand weeding registered least *E.colona* density, and was at par with the application of Pretilachlor fb by 2,4 DEE (1.0 and 0.5 Kg ha^{-1}). Further observation with various herbicidal treatments, application of Pretilachlor fb by 2,4 DEE (1.0 and 0.5 Kg ha^{-1}) was found effective in controlling *E.crusgalli* and significantly better to rest of the treatments except hand weeding twice.. .Application of Anilofos +2,4 -DEE (1.0 + 0.5 Kg ha^{-1}) registered low weed population during the second year of experiment at 30 DAT, and showed parity with the Pretilachlor fb by 2,4 DEE (1.0 and 0.5 Kg ha^{-1}) for controlling *E.crusgalli* (Table 2). Amongst all the treatments grassy weed biomass was least registered with the application of Pretilachlor fbby 2, 4 DEE (1.0 and 0.5 Kg ha^{-1}), and was significantly better than other set of chemical treatments. This treatment was followed by incorporation of Pendimethalin fb 2,4 DEE (1.0 and 0.5 Kg ha^{-1}). Lowest grassy weed biomass was recorded with hand weeding and superior to all other treatments (Ghersa *et al.*, 2000). Further observation revealed that the application of Pretilachlor fb 2,4 DEE (1.0 and 0.5 Kg ha^{-1}) recorded minimum weed biomass in the first year at 30 DAT and was at par with the hand weeding twice, and in second year at 30 DAT which was at par with the incorporation of Pretilachlor (1.0 Kg ha^{-1}). Observation of total weed density at 60 DAT during the first year experiment revealed that incorporation of Pretilachlor fb 2,4 DEE (1.0 and 0.5 Kg ha^{-1}), recorded minimum weed density, and significantly better than other set of experiment except the hand weeding twice, which registered least total weed density. However in the second year of experiment addition of Pretilachlor fb 2,4 DEE (1.0 and 0.5 Kg ha^{-1}) showed parity with the incorporation of Anilofos +2,4 -DEE (1.0 + 0.5 Kg ha^{-1}) and Pretilachlor (1.0 Kg ha^{-1}) and significantly better than other set of chemical treatment to check the total weed population in research plot.

Table 1. Important characteristics distinguishing the three species of Echinochloa in rice field under mid hill situation.

Characters	*Echinochloa colona* (L.) Link	*Echinochloa crus-galli* (L.) P. Beauv
Common name	Jungle rice, awnless barnyard grass	Common barnyardgrass
Habit	Paddy fields, Upland crops	Low land rice, seasonal swamps and drainage dithches.
Growth habit	Procumbent	Erect
Life span	Annual,A tufted annual grass	Annual, tufted or reclining at base.
Plant height (cm)	60-70	180-200
Stem	Reddish purple or green, ascending to erect, without hairs.	Culms rooting at lower nodes, cylindrical, without hairs, and filled with white spongy pith.
Leaf	linear, 12 – 16 cm long, basal portion often tinged with red; ligule absent.	linear with a broad round base and narrow top, blade 10-40 cm long, ligule absent.
Inflorescence	Simple, ascending racemes, green to purple, about 7-13 cm long, spikelets subsessile 1- 4 mm long.	Inflorescence: loose green to purplish, 15-23 cm long comprising compound racemes, spikelets more or less elliptical and pointed, usually slightly hairy, awns, if present, green to purplish, 2-5 mm long.
Flowering time	*Echinochloa colona* flowers throughout the year and is propagated by seeds. Seeds have a short dormancy period.	Propagates by seed. Flowers throughout the year and can produce seeds within 60 days.
Panicles	Relative small	Variable in length
Arrangement of spike	Arranged in four to three rows	Discrete arrangement
Awn	Awnless	Awned
Stigma color	Purpule to black	Light Pink
Anther color	Purple	Brown or yellow
Seed production/plant	200-400	510-812
Seed dormancy	Less variable	High
Grain shattering fully ripe	High	Variable but less
Appearance of plant	Dark green	Pale green
Cultural control	Flooding, hand weeding or use of a hoe during early growth stages.	Wet or dry conditions can reduce infestations. Difficult to distinguish the weed seedlings from rice at early stages, this makes hand weeding difficult.

Amongst all the treatments hand weeding twice registered lowest total weed biomass during the both the year of observation and significantly better than all other weed control practices (Table 3). Maximum weed biomass was found with the unweeded plot during both the years. Amongst various chemical treatments, minimum weed biomass was registered with the incorporation of Pretilachlor fb 2,4 DEE (1.0 and 0.5 Kg ha^{-1}) and was statistically superior to other set of experiment during the first year of at 30 DAT. However in the second year of 30 DAT this treatment was at par with the Pretilachlor (1.0 Kg ha^{-1}) and statistically better than other chemical treatment practices. Total weed biomass at 60 DAT revealed that addition of Pretilachlor fb 2,4 DEE (1.0 and 0.5 Kg ha^{-1}) recorded least weed biomass production and significantly better than other set of experiment except hand weeding twice, however in second year it showed parity with the Pretilachlor (1.0 Kg ha^{-1}), Pendimethalin fb 2,4 DEE (1.0 and 0.5 Kg ha^{-1}), Anilofos +2,4 –DEE (1.0 and 0.5 Kg ha^{-1}) and Anilofos (1.0 Kg ha^{-1}), and statistically better than other inorganic treatment practices. Maximum weed control efficiency was recorded with the hand weeding twice and was followed by Pretilachlor fb 2,4 DEE (1.0 and 0.50 Kg ha^{-1}) and Anilofos +2,4 –DEE (1.0 + 0.5 Kg ha^{-1}). Further weed index was least recorded with the Pretilachlor fb 2,4 DEE (1.0 and 0.5 Kg ha^{-1}) and was closely followed by Pretilachlor (1.0 Kg ha^{-1}).

The yield of a crop is net result of the extent of successful growth and developmental activities in individual plant, which in turn would depend upon the genetic potential of the cultivars and the environmental condition to which it is exposed during the course of

Table 2. Effect of treatments on *Echinochloa* sp, grassy weed biomass and total weed density.

Treatment [2])	Dose (kg ha^{-1})	*Echinochloa colona* (No m^{-2})				*Echinochloa crusgalli* (No m^{-2})				Grassy weed biomass (g m^{-2})				Total weed density (N om^{-}			
		30 DAT		60 DAT		30 DAT		60 DAT		30 DAT		60 DAT		30 DAT		60 DAT	
		2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Unweeded	-	5.70* (32.00)	5.21 (26.67)**	5.15 (30.33)	6.09 (36.67)	3.48 (11.66)	3.62 (12.67)	3.54 (12.00)	3.89 (14.67)	5.53 (30.11)	5.92 (34.13)	7.89 (61.83)	7.32 (53.13)	12.32 (151.33)	13.56 (183.33)	15.19 (230.33)	15.85 (250.66)
Hand weeding (25 and 50 DAT)	-	2.12 (4.00)	1.87 (3.23)	1.35 (1.33)	0.91 (0.33)	0.71 (0.00)	1.05 (0.67)	0.71 (0.00)	0.71 (0.00)	0.85 (0.23)	1.19 (0.92)	0.95 (0.41)	1.01 (0.53)	6.0 (36.11)	4.69 (21.50)	1.68 (2.33)	2.32 (4.86)
Pendimethalin	0.5	3.76 (13.66)	4.05 (15.96)	5.08 (25.33)	4.70 (21.67)	2.92 (8.00)	3.19 (9.67)	3.81 (14.00)	3.81 (14.00)	4.07 (16.07)	4.54 (20.13)	4.45 (19.33)	5.25 (27.10)	10.47 (109.33)	9.42 (88.33)	12.06 (145.00)	12.20 (148.33)
Pendimethalin	0.75	3.29 (10.33)	2.86 (7.67)	3.98 (15.33)	4.34 (18.33)	2.55 (6.00)	2.80 (7.33)	3.03 (8.67)	3.13 (9.33)	4.08 (16.13)	4.17 (16.90)	4.60 (20.67)	4.86 (23.10)	9.2 (85.66)	8.22 (67.11)	11.26 (126.33)	11.68 (136.00)
Pendimethalin	1.0	2.97 (8.33)	3.08 (9.00)	3.71 (13.33)	4.33 (18.33)	2.55 (6.00)	2.48 (5.67)	3.03 (8.67)	3.08 (9.00)	3.72 (13.40)	4.07 (16.07)	4.56 (20.33)	4.78 (22.40)	6.84 (46.33)	7.36 (53.67)	10.09 (101.33)	11.39 (129.33)
Pretilachlor	0.5	4.22 (17.33)	3.85 (14.33)	3.81 (14.00)	4.30 (18.00)	2.55 (6.00)	2.39 (5.33)	3.03 (8.67)	3.08 (9.00)	4.18 (17.00)	4.43 (19.07)	4.98 (24.33)	5.22 (26.80)	9.78 (95.33)	8.71 (75.34)	11.74 (137.33)	10.58 (111.05)
Pretilachlor	0.75	3.71 (13.33)	4.12 (16.50)	3.58 (12.33)	4.14 (16.67)	2.12 (4.00)	2.12 (4.00)	2.86 (7.67)	3.03 (8.67)	4.08 (16.13)	4.16 (16.83)	4.67 (21.33)	5.04 (24.97)	8.37 (69.67)	8.19 (66.66)	11.39 (129.33)	10.70 (114.00)
Pretilachlor	1.0	2.85 (7.67)	2.55 (6.00)	3.67 (13.00)	3.44 (11.33)	2.12 (4.00)	2.10 (4.00)	2.79 (7.33)	2.86 (7.67)	3.87 (14.50)	3.34 (10.63)	4.45 (19.33)	4.62 (20.83)	6.06 (36.33)	5.70 (32.00)	10.07 (101.00)	10.14 (102.34)
Pendimethalin fb 2,4 DEE	1.0 and 0.5	2.79 (7.33)	3.03 (8.67)	3.39 (11.00)	4.06 (16.00)	1.58 (2.00)	1.68 (2.33)	2.74 (7.00)	2.80 (7.33)	3.58 (12.37)	3.09 (9.09)	3.95 (15.11)	4.26 (17.67)	7.18 (51.11)	7.12 (50.11)	9.95 (98.66)	9.90 (97.67)
Pretilachlor fb 2,4DEE	1.0 and 0.5	2.01 (3.56)	1.83 (2.86)	2.19 (4.33)	2.55 (6.00)	1.22 (1.00)	1.58 (2.01)	1.58 (2.00)	1.66 (2.33)	1.72 (2.47)	1.61 (2.10)	3.12 (9.33)	3.44 (11.33)	5.21 (26.66)	5.02 (24.67)	6.64 (43.66)	7.51 (56.00)
Anilofos	1.0	3.58 (12.33)	3.49 (11.67)	4.38 (18.67)	4.78 (22.33)	3.03 (8.67)	3.08 (9.00)	3.62 (12.67)	3.08 (9.00)	3.93 (15.00)	4.03 (15.90)	4.67 (21.33)	4.88 (23.33)	9.68 (93.33)	7.81 (60.34)	10.53 (110.33)	11.27 (126.66)
Anilofos +2,4 DEE	1.0 + 0.5	5.61 (6.33)	2.33 (5.00)	3.13 (9.33)	3.67 (13.00)	1.58 (2.00)	1.46 (1.67)	2.35 (5.00)	2.20 (4.33)	3.75 (13.57)	3.80 (13.97)	4.45 (19.33)	4.66 (21.27)	7.79 (60.33)	7.05 (49.33)	8.84 (77.67)	9.58 (91.33)
SEm±		0.21	0.14	0.11	0.06	0.8	0.13	0.11	0.13	0.04	0.09	0.03	0.13	0.30	0.134	0.40	0.98
CD (P<0.05)		0.73	0.36	0.24	0.19	0.21	0.41	0.21	0.31	0.14	0.31	0.16	0.37	0.84	0.98	1.09	2.71

*Data subjected to square root transformation. ** Figure in parenthesis is original value.

Table 3. Effect of treatments on total weed density, weed control efficiency, weed index and yield of rice.

Treatment	Dose	Total weed biomass (g m^{-2})				Weed control efficiency (%)				Weed index(%)		Grain yield(t ha^{-1})		Straw yield(t ha^{-1})	
	(kg ha^{-1})	30 DAT		60 DAT		30 DAT		60 DAT							
		2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Unweeded	-	8.19* (66.66)**	9.14 (83.13)	11.13 (123.80)	11.77 (137.74)	-	-	-	-	57.75	62.98	2.21	1.85	3.87	2.80
Hand weeding (25 and 30)	-	1.61 (2.10)	1.35 (1.33)	3.54 (12.10)	2.70 (7.01)	96.8	98.4	90.22	94.91	-	-	5.23	5.00	6.80	6.46
Pendimethalin	0.5	6.54 (42.33)	8.22 (67.13)	9.32 (86.50)	10.10 (101.67)	36.49	19.24	30.12	26.18	42.50	48.51	3.01	2.57	4.33	4.15
Pendimethalin	0.75	6.05 (36.20)	5.37 (28.44)	7.73 (59.37)	8.62 (73.90)	45.69	54.69	52.04	46.34	19.54	28.74	4.21	3.57	5.81	5.27
Pendimethalin	1.0	4.86 (23.13)	4.66 (21.23)	7.10 (50.00)	6.89 (46.67)	43.53	74.46	59.61	66.11	17.20	25.02	4.33	3.75	5.92	5.99
Pretilachlor	0.5	6.69 (44.33)	6.03 (35.94)	8.83 (77.60)	7.29 (52.69)	33.49	56.76	37.31	61.74	36.62	39.03	3.16	3.05	5.37	5.01
Pretilachlor	0.75	5.61 (31.03)	5.58 (30.70)	7.69 (58.64)	6.69 (44.33)	53.45	63.06	52.63	67.81	31.02	31.76	3.61	3.41	4.91	5.19
Pretilachlor	1.0	4.39 (18.83)	3.89 (14.63)	6.44 (41.10)	5.69 (31.90)	71.75	82.40	66.80	76.84	3.57	6.67	5.07	4.67	6.35	5.79
Pendimethalin fb 2,4 DEE	1.0 and 0.5	5.57 (30.57)	5.85 (33.70)	6.40 (40.53)	6.26 (38.76)	54.14	59.46	67.26	71.86	8.76	13.72	4.77	4.31	5.71	5.50
Pretilachlor fb 2,4DEE	1.0 and 0.5	2.90 (7.93)	3.89 (14.67)	4.60 (20.70)	5.65 (31.05)	88.10	82.35	83.27	77.45	2.06	1.41	5.13	4.93	6.65	6.16
Anilofos	1.0	4.91 (23.63)	5.07 (25.23)	6.66 (43.89)	7.06 (49.44)	64.55	69.64	64.54	64.10	26.32	7.61	3.85	4.62	5.16	6.31
Anilofos + 2,4 DEE	1.0+0.5	4.15 (16.76)	4.68 (21.44)	5.79 (33.13)	5.64 (31.40)	74.87	74.20	90.67	77.20	9.45	3.83	4.73	4.81	6.49	5.90
SEm±		0.32	0.36	0.33	0.41							0.03	0.07	0.08	0.12
CD (P<0.05)		0.91	0.81	0.95	1.02							0.10	0.21	0.23	0.36

*Data subjected to square root transformation. ** Figure in parenthesis is original value.

life cycle. All the weed control treatments significantly out yielded the weedy check with respect to grain yield. Among the crop-weed control measures compared as sub-treatments hand weeding recorded the lowest weed count and highest grain yield (5.23 t and 5.0 t ha^{-1}) and significantly better than other set of experiments except inclusion of Pretilachlor fb 2,4 DEE (1.0 and 0.5 Kg ha^{-1}) . Hand weeding twice at 25 and 50 DAT, registered 136.0 and 170.0% more grain yield over unweeded check during first and second years respectively, due to manual removal of existing vegetation of all the weeds (Mukherjee *et al*., 2006). Amongst various chemical treatment maximum grain yield of 5.13 t ha^{-1} was observed in first year with the application of Pretilachlor fb 2,4 DEE (1.0 and 0.5 Kg ha^{-1}) and was at par with the Pretilachlor (1.0 kg ha^{-1}). However, in second year amongst various herbicidal treatmenthighest grain yield of 4.93 tha^{-1} was registered with the application of Pretilachlor fb 2,4 DEE (1.0 and 0.5 Kg ha^{-1}), , and was at par with the Anilofos +2,4 DEE (1.0 + 0.5 Kg ha^{-1}) (4.81 t ha-^{1}). Pendimethalin (0.5 Kg ha^{-1}) application recorded least grain yield amid all herbicidal practices and was followed by Pretilachlor (0.5 Kg ha^{-1}). Increase in grain yield due to checking the populations of *E.colona* and *E.crusgalli* through chemical treatment were also reported by Chopra and Chopra (2003) and Singh *et al*. (2003).

Straw yield was highest with the hand weeding twice (6.80 and 6.46 t ha^{-1}), and was at par with the Pretilachlor fb 2,4 DEE (1.0 and 0.5 Kg ha^{-1}) and Anilofos +2,4 DEE (1.0 + 0.5Kg ha^{-1}) during first year of data recording, and in second year this was at par with the Pendimethalin (1.0 Kg ha^{-1}), Pretilachlor fb 2,4 DEE (1.0 + 0.5 Kg ha^{-1}) and Anilofos +2,4 DEE (1.0 + 0.5 Kg ha^{-1}). Least straw yield was recorded with the unweeded plot and was followed by Pendimethalin (0.5 Kg ha^{-1}) and Pretilachlor (0.5 Kg ha^{-1}).

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