Herbicide options for suitable weed management of transplanted rice in north-eastern ghat zone of odisha

ABSTRACT

A field study aimed to assess different weed management tactics in transplanted rice was demonstrated during rainy season in four villages of Ganjam district of Odisha under farmer participatory mode for two years (2019 and 2020). From the concluded research work, it was observed that application of pretilachlor (0.75 kg/ha) within 3 DAT followed by bispyribac sodium @ 25kg/ha at 25 DAT recorded the highest WCE (73.27%), grain (4186 and 4351 kg/ha) and straw yield (5349 and 5308 kg/ha). Hand weeding performed better with respect to WCE (80.1, 81.3 % at harvest) but net return (Rs. 37073 /ha, Rs. 38119 /ha) was found to be low. While Pretilachlor (0.75 kg/ha) within 3 DAT followed by bispyribac sodium (25 kg/ha) at 25 DAT recorded the highest net return (Rs. 41798/ha, Rs. 43956 /ha) and B:C ratio (1.87, 1.89) than other treatments.

Key words: Bispyribac sodium, grain yield, hand weeding, pretilachlor, WCE and weed density

1. INTRODUCTION

Rice, being the most important food grain in Asia, constitutes the major food supply for most of the world's population. India constitutes about 40-50% of rice production of the world from 42.1 million ha rice-growing areas. Traditionally Rice is cultivated by raising community nursery and month old seedlings are transplanted in a puddled and flooded soil condition. Weeds are ubiquitous and insidious tyrants on earth and are acknowledged as the most important biological limitations that obstruct to reach potential productivity and quality of rice (Rao and Nagamani [20]; Prakash *et al.* [19] and Hossain *et al.*, [9]). Figuring out ecological based weed control practices might be a potential alternative for controlling weeds in cropping systems taking rice as a component crop keeping an eye on climate change and diminishing resource inputs for farming. Self-seeded weeds emerge at the same time with rice plants initiating serious crop-weed competition for resources causing poor and weak plant stand. Presently, this has been tackled by manual hand weeding. However, this is a tedious, time consuming, costly and ineffective method where some of the rice associated weeds like *Echinochloa*

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crusgalli and *Echinocloa colonum* could not be separated owing to the resemblance between rice and weed seedlings. Nevertheless, the major factors owing to crop losses by weeds are location, duration of weed infestation and predominance of weed flora (Hakim *et al*. [7]). The negative consequences of weeds on the productivity of crops were supplemented with a harmful consequence on beneficial soil biota.

Diverse weed flora (grasses, BLWs and sedges) under transplanted conditions can bring about the reduction of yield up to 75-80% (Singh *et al.* [23]). In contemplation of obtaining utmost advantage of applied resource bases, 2-3 hand weedings (HW) were found to be most productive at odds with weeds in rice (Halder and Patra, [8]). Howbeit, uninterrupted and incessant rain during crop growing period, labor scarcity and high wage costs in the peak period of weed growth especially, at the early period of competition between crop-weed, make this operation more burdensome and unprofitable. As a consequence, farmers require second possible weed control strategies to manage weeds easily at a lower cost. Manual weeding (by hand) and mechanical weed control practices were the primary management techniques utilized by the farmers previously to the starting of research work on the field of herbicides in India. Weed management through the use of chemicals/herbicides was noted to be one of the productive and economic methods in the management of weed now-a-days. The main objective of herbicide use is to eradicate or arrest weed infestation allowing the rice to grow and gain a competitive advantage. The use of herbicides is being popular slowly among the farming community because of the most productive means of reducing crop-weed competition with minimal labor wage.

There are substantial rice areas in eastern India where weeds are a major threat to rice crop and rice production is economically impossible without suitable weed management strategies. Puddling for the seedling establishment of transplanted rice controls weeds initially during rice establishment and at the early tillering stage. It is reported that weed competition with rice starts around 20 days DAT (Mukherjee *et al.,* [16]). Hence, two hand weedings at three and six weeks after transplanting coinciding with tillering and panicle initiation stages of rice are generally practiced in India. Nevertheless, Indian farmers face serious problems in manual weed control due to labor scarcity, increased labor cost, great difficulty in differentiating rice and *Echinochloa colona* seedlings in the early growth stage and at the critical period of weed competition, resulting in ineffective weed management. In addition to hand weeding, some farmers in India also adopt herbicides to control weeds in rice fields due to their efficacy, cost and wider acceptability (Mahajan and Chauhan, [14], Wang *et al.*, [27] and Pinjari *et al.*, [18]). Nevertheless, the application of a very limited number of herbicides continuously such as butachlor in every growing season was rapidly connected with serious problems in weed management, such as weed flora shift and development of resistant biotypes to herbicide (Mahajan and Chauhan [14], Dass *et al.* [5]). Hence, the need for a broad spectrum post-emergence herbicide arises that will keep weed under control in the rice field, especially from 20 DAT. There is an acute need for enhancing the attempts to understand the ecology and biology of weeds for their better management. Keeping in view of the facts described above, this demonstration was undertaken to find out the herbicide options on the productivity of transplanted rice (*Oryza sativa* L.) in the North-Eastern Ghat Zone of Odisha.

2. SITE DESCRIPTION, MATERIALS & METHODS

A field trial under the RESILIENCE project was commenced during *the Kharif* seasons of 2019 and 2020 in the participatory mode in farmers' field at Lathipada (19.7769˚ N, 84.5275˚ E), Chikarada (19.2417˚ N, 84.7812˚ E), Sorisabilli (19.7713˚ N, 84.4409˚ E) and Sasanapadar (19.2242˚ N, 84.7916˚ E) villages of Ganjam district of Odisha. Ganjam is experiencing a hot dry summer having an annual rainfall of 1056-1306.80 mm on average and the mean minimum and maximum temperature are 21º C and 33.5º C, respectively. The soil of the experimental site was shallow depth, well-drained, sandy loam in texture, nearly neutral in reaction and variable soil status in all places. The experiment was carried out in randomized block design with 5 treatments *viz.* hand weeding at three & six weeks (farmers' practice), bispyribac - sodium @ 25 g/ha, pretilachlor @ 1.5 l/ha within 03 DAT + bispyribac sodium @ 25 g/ha at 25 DAT, weed-free check and weedy check in 7 locations. This experiment was done with rice variety Swarna sub-I in 15.8 ha area. A standardized basal dose of 40 kg N, 40 Kg P_2O_5, 40 kg K_2O and 25 kg Zn/ha were applied in all treatments. Top dressing of the remaining quantity of nitrogen (40 kg/ha) was done equally in two splits *i.e.* in active tillering and PI stages. The weed numbers were counted with a 50 cm × 50 cm quadrat at five random places per plot for evaluating the relative efficacy of treatments at 30, 60 and 90 DAT and weed density expressed as the number of weeds/m^2. Weed count and weed dry matter accumulation data were subjected to transformation. After counting, the weed samples were uprooted washed, oven-dried at 70 ^{0}C for 48 hours and dry weight was taken. Weed control efficiency (WCE) (Kabir *et al*. [11]) and weed index (WI) (Mishra and Mishra, [15]) were calculated using the standard procedure.

$$WCE = \frac{X-Y}{X} \times 100$$

Where, X is weed dry matter in the weed check plot, Y is weed dry matter in the treated plot

$$WI = \frac{a-b}{a} \times 100$$

Where, a is grain yield from weed free plot, b is the yield from treated plot

The economic yield of rice along with other yield parameters was recorded at harvest @ 14% seed moisture content. Samples were taken from an area of 1.0 m^2 from each treatment to determine above ground total dry weight (total biomass) and yield components. Panicles from the 1.0 m^2 area were counted manually. Filled grains of 10 randomly selected panicles were counted to find out the number of grains per panicle. Total biomass was calculated by adding straw dry weight and grain dry weight of each treatment. Statistical analysis of experimental data over the years was subjected to following standard procedure (Gomez and Gomez, [6]).

3. RESULT AND DISCUSSION

Observation of Weed flora in experimental site: Weed flora of the experimental plots comprised of different types of grasses, broadleaf weeds and sedges (Table 1).

The floristic composition of weeds in the experimental plot imparted that altogether 20 weed species comprised of 12 monocot weeds (10 types of grass, 2 sedges) and 8 broad-leaved weeds belonging to 8 families infested the experimental plots. It was observed that grasses, sedges and broad-leaved weeds comprised 46.56%, 10.05% and 43.39%, respectively of the total weed population. C*yperus difformis*, *Echinochloa glabrescens* and *Ludwigia adscendes* were the dominant weeds. Similar weed flora associated with rice has also been revealed by Sangeeta *et al.* [21]. It was reported that factors affecting community composition of these weeds are methods of crop establishment, cultural practices, cropping sequence, management of water and soil, location, weed management practices, climatic variability and natural weed flora of that area (Nagragade *et al.* [17]).

Table 1. Observation of weed flora of the experimentalsite during the period of experiment

Name of weeds	Family	Common name	Name of weeds	Family	Common name
A) Monocot weeds					
Cyperus iria	Cyperaceae	Yellow nut sedge	E. crusgalli	Poaceae	Barnyard grass
Fimbristylis	Cyperaceae	Hoorah grass	*Eleusine indica*	Poaceae	Goose grass

miliacea					
Leptochloa chinensis	Poaceae	Asian springletop	*Ischaemum rugosum*	Poaceae	Wrinkle grass
Paspalum distichum	Poaceae	Knot grass	*Oryza sativa*	Poaceae	weedy rice
Digitaria sanguinalis	Poaceae	Crab grass	*Dactyloctenium aegyptium*	Poaceae	Crowfoot grass
Echinochloa colonum	Poaceae	Jungle rice	*Cynadon dactylon*	Poaceae	Bermuda grass
B) Dicot weeds					
Alternathera philoxeroides	Amaranthacea e	Alligator weed	*Marsilia quadrifolia*	Marsiliacea e	Water clover
Commelina nodiflora	Commelinacea e	Day flower	*Monochoria vaginalis*	Pickerel weed	Pontederiaceae
Eclipta alba	Asteraceae	False daisy	*Sphenoclea zeylanica*	Goose weed	Sphenocleaceae
Ludwigia parviflora	Onagaceae	Water primerose	*Phyllanthes niruri*	Stonebreak er	Phyllanthaceae

Weed density: Weed density was recorded at 30, 60, 90 DAT and harvest are presented in table 2. From the data, it was revealed that there was a progressive increase in the total weed population from the initial stage. The weed-free plot recorded the lowest weed population followed by pretilachlor (0.75 l/ha) within 03 DAT + bispyribac sodium (25 g/ha) at 25 DAT all over the crop growth period. The plots receiving hand weeding also recorded significantly lesser grassy weed population at all crop growth stages. The weedy check plot recorded maximum grassy weeds at all stages of crop growth. Hand weeding twice at 03 and 06 weeks recorded a lower weed density similar to pretilachlor @ 0.75 l/ha within 03 DAT + bispyribac sodium @ 25 g/ha at 25 DAT. The bispyribac sodium herbicide is very effective in managing grasses and BLWs in wetland rice cultivation. This might be due to efficient broad-spectrum control resulting in total weed density control by combining both pre and post-emergence application of pretilachlor + bispyribac. Similar results were also corroborated by Prakash *et al.* [19] and Sumekar *et al.* [25]).

Weed dry weight: Weed dry weight was influenced by different weed control practices at different crop growth stages were presented in Table 2. The minimum weed dry weight was registered with a weed-free plot followed by hand weeding (9.93, 13.14, 18.86 g/m^2 at 30, 60 and 90 DAT) closely followed by pre-emergence application of pretilachlor @ 0.75 l/ha within 3 DAT along with bispyribac sodium @ 25 g/ha at 25 DAT that significantly decreased weed dry weight during different crop growth stages. The weed dry weight was found to be lower in pretilachlor @ 0.75 l/ha within 3 DAT along with bispyribac sodium @ 25 g/ha at 25 DAT at initial stages but at later stages hand weeding performed better. However, with bispyribac sodium application, weed growth was suppressed. Effectiveness of Post-emergence application of bispyribac-sodium alone and along with pretilachlor was documented against diverse weed flora in transplanted rice (Walia *et al.,* [26], Yadav *et al.,* [28] and Kumar *et al.,* [13]).

Yield attributes, Yield and Economics: A close perusal of the data indicated that the weed-free plot produced the highest yield attributes viz. effective tillers, panicle length and grains/panicle in rice. Among herbicide treatments, pretilachlor (0.75 l/ha) within 3 DAT along with bispyribac sodium (25 g/ha) at 25 DAT had a significant effect on enhancing effective tillers (13.98, 14.20) over other weed control treatments. Significantly higher effective tillers, as well as grain and straw yield, were recorded during the second year of study over the first year. Panicle length (19.0 and 19.71 cm), grains/panicle (99.86 and 100.43), grain yield (4186 and 4351 kg/ha) and straw yield (5349 and 5308 kg/ha) of rice were significantly higher in pretilachlor @ 0.75 l/ha within 03 DAT along with bispyribac sodium @ 25 g/ha at 25 DAT followed by bispyribac sodium at 25 g/ha (3990 and 4125; 5116 and 5178 kg/ha) and significantly superior over weedy check plots. The maximum harvest index was observed in weed-free plot. Timely control of weeds in the critical period of crop growth and maintenance of less weed population all over crop growth stages attributes to higher yield in transplanted rice. Similar results are also reported by Kabdal *et al.,* [10] and Sreelakshmi *et al.,* [24]. Grain yield level was determined by vegetative stage from the beginning of generation and ripening phase in plant growth. Thus due to the availability of soil nutrients optimally, there will be an increase in nutrient uptake by the crop so that the growth and production levels are increased optimally. There will be an increase in growth components and yield components which increases the dry matter production (Antralina *et al.,* [2] and Satpathy *et al.,* [22]). The higher gross return of Rs. 90203 and Rs. 93666, net return of Rs. 41798 and 43823 during both years, respectively with BC ratio of 1.87 & 1.89 were realized with the application of pretilachlor followed by bispyribac sodium due to higher WCE, yield which fetches a higher incentive price than the cost involved. The above findings are in line with those of Anwar *et al.* [3] and Biswas *et al.* [4].

The relationship between density/biomass of weeds and grain yield were presented in Figure 1. and Figure 2. showed that there is an inverse relationship between weed density/biomass and grain yield. A determination factor of more than 0.7 shows that there is a strong relationship between them and with an increase in density and biomass of weed, grain yield decreases steeply. So, to enhance the productivity of rice there should be more focus laid on the agronomic practices to control weeds.

Weed control efficiency (WCE): The weed control efficiency (%) was documented at different crop growth stages and presented in Table 4. It varied significantly among different treatments with crop growth stages. Among weed management treatments, a maximum WCE of 73.27% was observed with pretilachlor @ 0.75 l/ha within 3 DAT along with bispyribac sodium @ 25 g/ha at 25 DAT which is significantly higher over bispyribac sodium (25 g /ha) and statistically at par with hand weeding treatment. Hand weeding twice at 3 and 6 weeks had 13.42% less weed control efficiency than the combined treatment of pretilachlor and bispyribac sodium at harvest. This might be because of the application of pretilachlor as a pre-emergence herbicide that suppresses the early emerged weed and bispyribac sodium suppressed the late emerged weed which lowers the population of weeds during the peak period of crop-weed competition. Corroborative reports were given by Prakash *et al.* [19], Kumar *et al.* [12], Kumar *et al.*, [13] and Ahmed et al. [1].

Weed index (WI): The weed index (%) was calculated at harvest and is given in Table 4. The weed index varied in different treatments with crop growth stages. The weed index ranged between 0 to 29.2 % in the weed control treatments. The weedy check plot registered the maximum weed index of 29.2 and 28.6 % in both years. Competition of rice plants with weeds reduces the availability of nutrients needed for rice growth; the longer the rice is associated with weeds the higher the influence on competition. The herbicide treatment bispyribac sodium can reduce yield losses due to lower competition of weeds with rice crops resulting in optimal plant growth and higher yield. The objective of weed control is to minimize the damage to plant biology caused by weeds, more specifically revealing that weed control is crucial to suppress yield loss due to weed competition as reported by Kumar *et al.* [12], Kumar *et al.*, [13] and Ahmed et al. [1].

4. CONCLUSION

New aged weed management strategies are demonstrated in farmers' fields through different methods resulting in benefits for farmers. Hence, Constant attempts are the need of the hour to check weed flora and its shift for developing new generation weed management strategies taking various ecosystems into account. Looking at the current scenario, labor shortage and labor cost that increases the cost of cultivation, broad-spectrum herbicides that are crop-specific are preferred. Based on this experiment, application of pretilachlor (0.75 l/ha) (pre-emergence) within 3 DAT along with bispyribac sodium (25 g/ha) (post-emergence) at 25 DAT should be recommended for practicing by farmers as this gives a broad spectrum weed control (1.5, 1.4 % Weed index at harvest), resulting in a longer weed-free period for the crop growth which enhances yield level (4186.0, 4351.6 kg/ha) and ultimately brings more profit (Rs. 41798, 43956 /ha) to the farmers in both the years.

5. COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Table 2. Effect of various weed management practices on population and dry weight of weeds

Treatment	No. of weeds /m^2								Weed dry weight (g /m^2)							
	30 DAS		60		90		At harvest		30		60		90		At harvest	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Hand weeding at 03 & 06 weeks	3.91 (14.29)	3.81 (13.57)	4.52 (19.43)	4.31 (17.57)	5.55 (29.86)	5.36 (27.71)	5.90 (33.86)	5.63 (30.71)	3.30 (9.93)	2.90 (7.93)	3.92 (14.43)	3.42 (10.75)	4.45 (18.86)	4.24 (17.00)	4.77 (21.86)	4.52 (19.50)
Bispyribac – sodium (25 g /ha)	5.19 (26.00)	4.97 (23.71)	7.08 (49.14)	6.97 (47.57)	7.29 (52.14)	7.09 (49.29)	7.56 (56.14)	7.30 (52.29)	4.21 (16.73)	3.77 (13.26)	5.43 (28.50)	4.95 (23.57)	5.69 (31.43)	5.30 (27.14)	5.94 (34.29)	5.54 (29.64)
Pretilachlor @ 0.75 lt./ha within 03 DAT & Bispyribac sodium @ 25 g/ha. at 25 DAT	3.91 (149.2)	3.66 (12.43)	5.29 (27.14)	5.08 (24.86)	5.32 (27.29)	5.09 (25.00)	5.68 (31.29)	5.38 (28.00)	2.70 (6.31)	2.35 (4.55)	4.88 (22.83)	4.65 (20.59)	5.44 (28.71)	5.16 (25.86)	5.71 (31.71)	5.40 (28.36)
Weed free	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)
Weedy Check	10.39 (106.92)	9.79 (94.78)	11.62 (134.16)	11.19 (124.28)	12.39 (152.51)	11.94 (141.70)	12.55 (156.51)	12.07 (144.7)	6.34 (39.22)	5.98 (34.87)	9.82 (95.49)	9.53 (89.86)	10.39 (106.92)	10.06 (100.24)	10.53 (109.92)	10.18 (102.74)
SEM(±)	0.06	0.06	0.08	0.07	0.07	0.08	0.06	0.07	0.05	0.14	0.09	0.08	0.09	0.11	0.09	0.11
CD at 5%	0.18	0.18	0.23	0.19	0.20	0.22	0.19	0.22	0.16	0.41	0.27	0.24	0.27	0.32	0.26	0.31

(The data were subjected to $\sqrt{x + 0.5}$ transformation and values in parentheses are original)

Table 3 (a). Effect of various weed management practices on yield and economics of rice

Treatment	Grain yield (kg/ha)		Straw yield (kg/ha)		Harvest Index (%)		Cost of Cultivation(Rs.)		Gross Return (Rs.)		Net income (Rs.)		B:C	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Hand weeding at 03 & 06 weeks	3752.1	3942.8	4759.1	4674.3	43.9	45.3	52497	51361	89570	89480	37073	38119	1.73	1.75
Bispyribac – sodium (25 g /ha)	3990.4	4124.8	5116.1	5178.4	43.4	44.0	44928	49485	82030	91762	37102	42277	1.83	1.86
Pretilachlor @ 0.75 lt./ha wit in 03 DAT & Bispyribac sodium @ 25 g/ha at 25 DAT	4186.0	4351.6	5348.9	5307.6	43.7	44.7	48405	49709	90203	93666	41798	43956	1.87	1.89
Weed free	4248.1	4414.1	5320.4	5286.0	44.4	45.3	53731	48349	81741	74920	36291	37432	1.60	1.63
Weedy check	3001.7	3154.3	5192.6	4663.3	37.6	41.0	61146	60242	97436	97673	28009	26571	1.54	1.56
SEM(±)	65.6	32.3	274.0	243.1	1.3	1.1	3874	3219	4804	4563	1535	1630	0.04	0.03
CD at 5%	196.5	94.69	NS	NS	3.8	N.S	NS	NS	NS	13399	4506	4787	0.12	0.08

Table 3 (b). Effect of various weed management techniques on yield attributes of rice

Treatment	No. of effective tiller/hill		Panicle length (cm)		Number of grains $panicle^{-1}$	
	2019	2020	2019	2020	2019	2020
Hand weeding at 03 & 06 weeks	12.31	12.39	15.14	16.86	96.71	95.86
Bispyribac – sodium (25 g/ ha)	13.82	14.01	17.57	18.66	97.71	99.00
Pretilachlor @ 0.75 lt/ha within 03 DAT & Bispyribac sodium @ 25g/ha at 25 DAT	13.98	14.20	19.00	19.71	99.86	100.43
Weed free	14.11	14.38	19.29	19.99	99.86	100.86
Weedy check	7.46	7.86	13.14	13.29	92.43	93.57
SEM(±)	0.37	0.26	1.07	0.49	1.35	1.03
CD at 5%	1.09	0.76	3.15	1.43	3.97	3.04

Table 4. Effect of various weed management techniques on Weed Control Efficiency and Weed index of rice crop

Treatment	WCE (%)								Weed index at harvest (%)	
	30 DAS		60 DAS		90 DAS					
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Hand weeding at 03 & 06 weeks	74.64	77.60	84.91	88.01	82.33	83.04	80.10	81.03	11.50	10.80
Bispyribac – sodium (25 g /ha)	57.29	73.71	70.00	73.71	70.57	72.91	68.79	71.14	6.00	6.60
Pretilachlor @ 0.75 lt/ha within 03 DAT & Bispyribac sodium @ 25 g/ha at 25 DAT	83.84	77.01	75.99	77.01	73.19	74.19	71.16	72.37	1.50	1.40
Weed free	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00	0.00
Weedy check	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.20	28.60
SEM(±)	0.89	0.76	0.84	0.76	0.85	1.07	0.84	1.05	1.40	0.80
CD at 5%	2.61	2.23	2.45	2.23	2.51	3.15	2.47	3.08	4.10	2.30

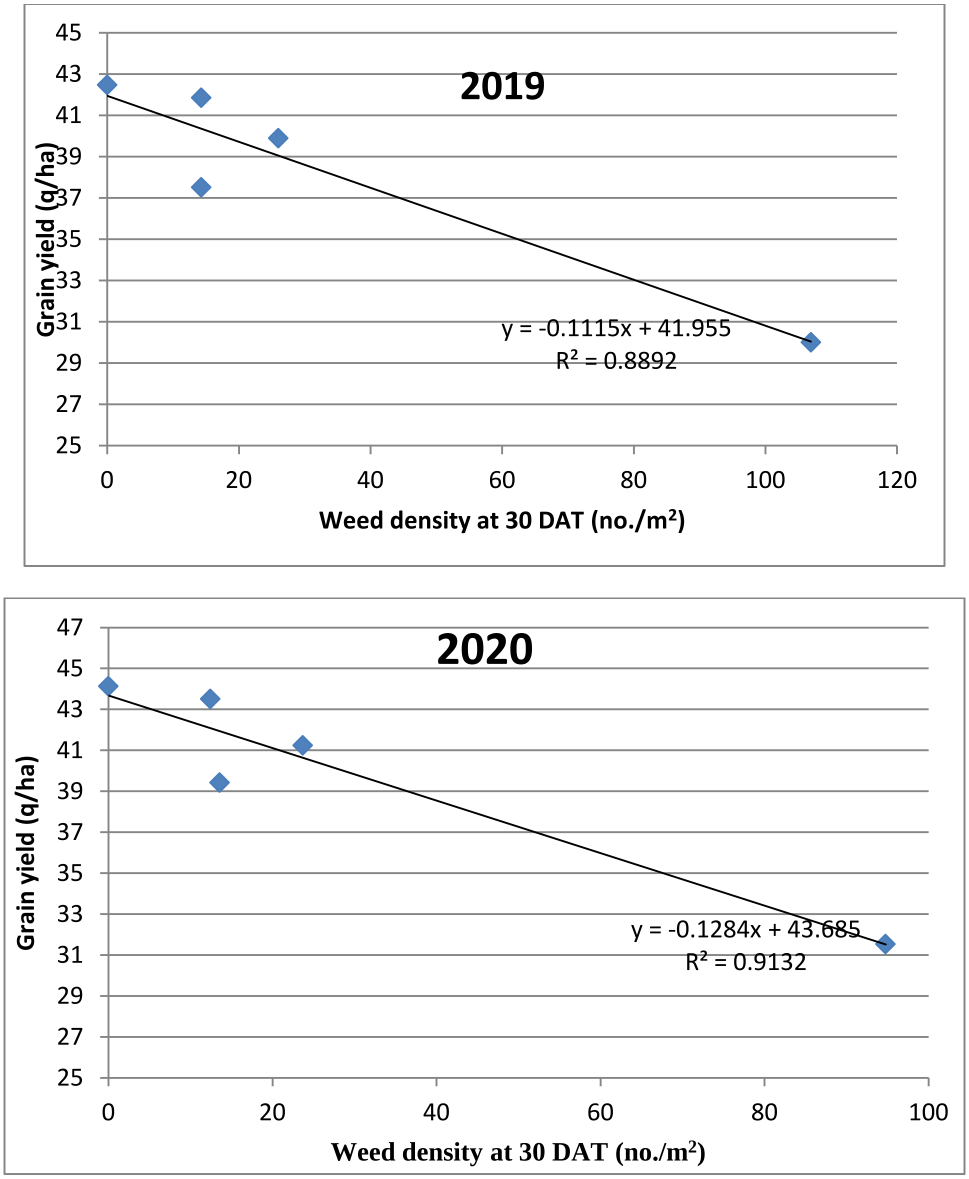

Figure 1: Relationship between weed density and grain yield of crop

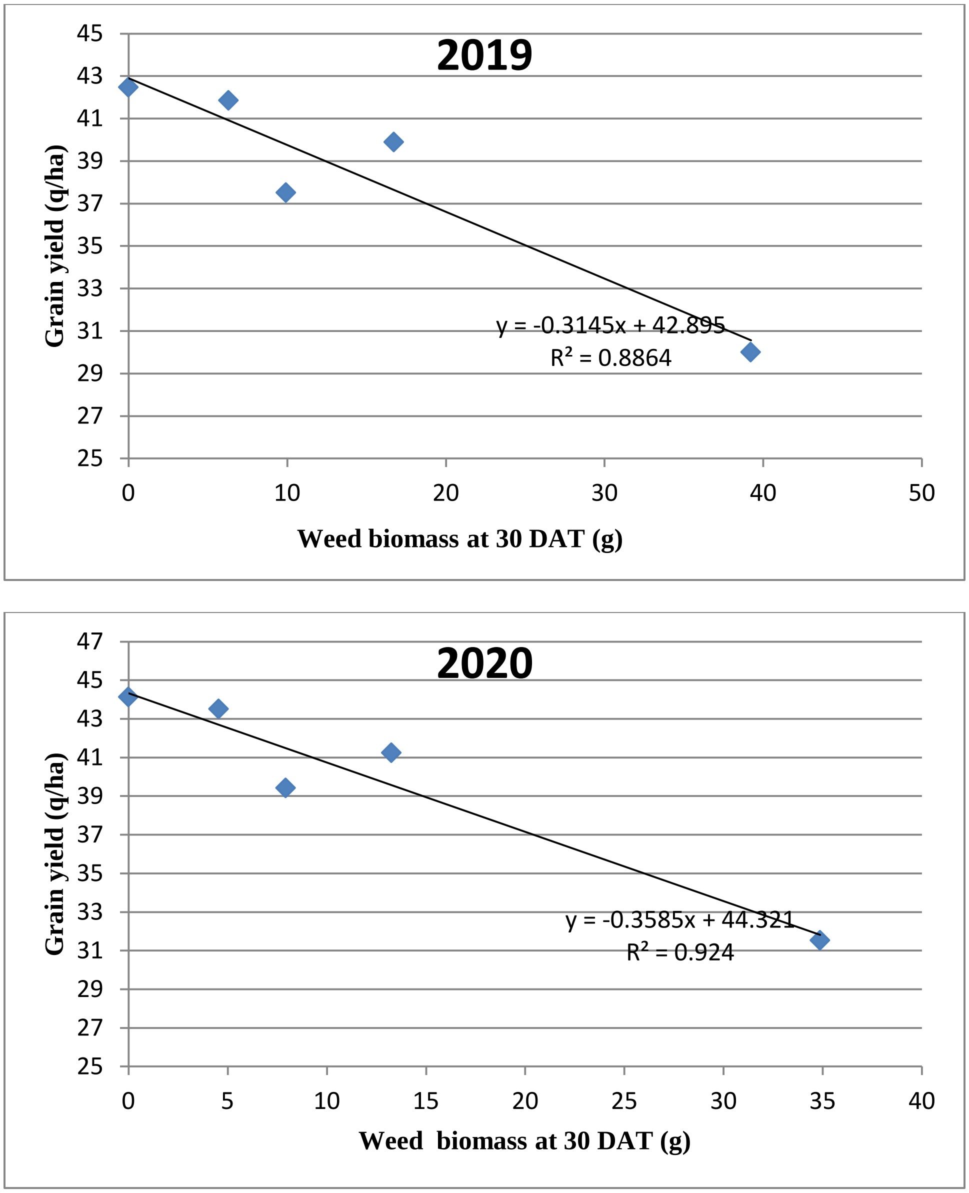

Figure 2: Relationship between weed biomass and grain yield in both the years