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Impact of integrated weed management on weed population and rice yield in Himachal Pradesh

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Abstract

The present investigation aimed to evaluate the “Effect of integrated weed management on weed density and yields of rice in Himachal Pradesh” during the *kharif* season of 2025 at the Instructional Farm, Department of Agronomy, School of Agriculture, Abhilashi University, Mandi (H.P). The study was conducted using a Randomized Block Design with 9 treatments each replicated thrice. Soil of the experimental field was acidic in nature, medium in organic carbon, low in available nitrogen, medium in available phosphorus and available potassium. The major weeds associated with transplanted rice were: *Echinochloa colona*, *Commelina benghalensis* and *Ageratum Conzyoides* each constituting 27.43%, 16.00% and 12.57%, respectively, of the total weed population. *Digiteria sanguinalis* and *Bidens pilosa* constituted about 10.29% and 19.43%, respectively of total weed population at maximum weed population stage. Occurrence of other weeds viz. *Aeschynomene indica*, *Oxalis latifolia* and *Polygonum alatum* was also seen during the crop season. They together constituted 14.28% of total weed flora during the experiment. The results indicated that the weed free treatment recorded the lowest weed count, total weed count, total weed dry weight, weed index and yield parameters of transplanted rice due to complete elimination of weed competition throughout the crop growth period. However, among the herbicidal treatments, the application of pendimethalin @ 1.0 kg a.i. ha⁻¹ (pre-emergence) followed by 2,4-D @ 0.5 kg a.i. ha⁻¹ at 45 DAT proved to be the most cost-effective treatment. In contrast, the weedy check treatment recorded the highest weed count, total weed count, total weed dry weight and weed index due to severe weed competition between weeds and crop. The study suggests that integrated use of pendimethalin followed by 2,4-D can be an effective weed management practice for transplanted rice.

Keywords: *Echinochloa colona*, rice, pendimethalin, 2,4-D, weed count

Introduction

Rice (*Oryza sativa* L.) crop provides food for almost half of the world’s population, accounting for over 21% of human caloric requirement and up to 76% of calorific intake of southeast-Asian inhabitants (Mohidem *et al.* 2022) [17].

Rice is the life-blood of the Asia-Pacific Region where 56% of humanity lives, producing and consuming more than 90% of the world rice. Rice contributes 43% of total food grain production and 46% of the cereal production of India. Rice is the staple food of about 3.5 billion people and demand is expected to continue to grow as population increases (Anonymous 2013) [3]. Globally, rice was demand is expected to the increase by 25.00% from the year 2001 to 2026 to meet the requirement of increasing world population (Rosegrant *et al.* 2002) [22]. Globally, total rice area is about 168 million hectares, production is 543 million metric tons with productivity of 4.3 tons per hectare (Anonymous 2024-25) [6]. Being one of the most important crops and second only to maize as *kharif* crop of Himachal Pradesh. It is grown in an area of 71.81 thousand hectares with a production of 114896 metric tonnes and productivity of 1600 kg ha⁻¹ in Himachal Pradesh (Sharma *et al.* 2022) [24].

Weeds are a serious challenge to rice production because of their ability to compete for resources and their impact on product quality. Rice production is severely hampered by weeds; in severe situations, the entire crop may be lost. Soil, climate, cropping, and management factors all affect the composition and level of competition of weeds, which are dynamic. The surrounding environment and cropping methods have a significant impact on the overall number of weed species in a field. Reducing weed populations to the point that they no longer affect

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farmers' ecological and financial interests is the goal of weed control. By using a range of efficient weed management approaches, farmers can lower the probability of escapes and weed adaptation to any one weed management strategy (Singh *et al.* 2020)^[27].

Major weeds affecting rice include *Echinochloa colona* and *E. crus-galli*, which are prevalent across all rice cultivation methods. Other notable weeds include *Avena sp*, *Amaranthus sp*, *Commelina sp*, *Cyperus rotundus* and *Cynodon dactylon*, with *E. colona* often dominating dry-seeded rice due to its lower moisture requirements compared to *E. crus-galli*. Notably, significant variation occurs in the prevalence of these weed species depending on crop establishment techniques and weed control methods.

Weed management must aim at reducing the weed population to a level at which weeds occurrence has no effect on farmers economic and ecological interests. By using different appropriate management practices against weeds, farmers have more options for controlling weeds, thereby reducing the possibility of escapes and weed adaptation to any single weed management tactic. Hand weeding is the most common practice of weed control. It provides clean and thorough weeding and maintains purity/quality of harvested grain. Manual weeding, though effective is getting increasingly difficult due to labour scarcity, rising wages and its dependences on weather conditions. Moreover, allowing weeds to reach sufficient size to be pulled out and the presence of perennial weeds that fragment on pulling are other related concerns (Khaliq *et al.* 2011)^[10].

Thus, herbicides usage seems indispensable for weed management in transplanted rice. Several pre-emergence herbicides like pendimethalin and butachlor applied either alone or supplemented with hand weeding have been reported to provide fairly adequate weed suppression in transplanted rice (Baloch *et al.* 2005)^[8]. Pendimethalin, a member of the dinitroaniline herbicide class, is widely used as a pre-emergence treatment in rice to suppress annual grassy and broadleaf weeds. Its primary mode of action is inhibition of microtubule polymerization, which disrupts cell division and root elongation in germinating weed seedlings (Alvarez and Khatib. 2024)^[1].

One of the herbicides that can be used to control weeds in rice is the butachlor herbicide. Butachlor herbicide is a systemic herbicide and is selective in the acetanilide class of the Chloroacetamide group of compounds used to control annual grass weeds and some broadleaf weeds in nurseries or rice plantations (Tomlin, 2010)^[29]. Another herbicide used in rice crop to control the weed is Anilofos (selective organophosphorus herbicide) widely used in transplanted and direct-seeded rice for pre-emergence and early post-emergence control of annual grasses, sedges and some broad-leaf weeds. It is absorbed primarily from the soil by emerging seedlings and to a lesser extent by young foliage, and it acts on meristematic tissues to inhibit cell division and elongation, thus preventing establishment of germinating weed seedlings. (Sondhia and Dixit. 2015)^[28].

In this scenario, post emergence herbicides like 2,4-D, appears to be superior. 2,4-D, is a contact herbicide for post control of grasses, broad leaf and sedges weeds in rice. (Kumar *et al.* 2014)^[11] reported effectiveness of 2,4-D, to control grassy weeds and sedges in transplanted rice. 2,4-dichlorophenoxyacetic acid, commonly referred to as 2,4-D, will control certain broad-leaf plants without at the same time materially injuring most true grasses has aroused considerable interest on the part of rice growers. Sufficient information has accumulated during the last two years both from experimental tests and from commercial

applications to show that 2,4-D will control certain rice weeds at a relatively low cost per acre (Peterson *et al.* 2016)^[19].

Materials and Methods

A field experiment was carried out on transplanted rice during *kharif* season of 2025 at the Research Farm, Department of Agronomy, School of Agriculture, Abhilashi University, Chail Chowk Distt. Mandi (H.P). This experiment focused on the cultivation of transplanted rice *var.* PAC 807 Plus during the *Kharif* season of 2025. Sowing of the nursey for transplanting on May 15, 2025. After the nursery period is complete, the rice is then transferred to the land that has been provided and transplanting on July 01, 2025. The design was Randomized Block Design in which the gross plot size was 3m × 2m, totaling 6 square meters, while the net plot size, the actual experimental area was 2.5 m × 1.5m, equivalent to 3.75 square meters. The study included 9 different treatments *i.e.* T₁ - Weedy check, T₂ - Weed free, T₃ - 2 hand weeding at 10 DAT & 45 DAT, T₄ - Pendimethalin @ 1.0 kg a.i. ha⁻¹ (pre- emergence) + one hand weeding at 45 DAT, T₅ - Pendimethalin @ 1.0 kg a.i. ha⁻¹ + 2,4-D @ 0.5 kg a.i. ha⁻¹ at 45 DAT, T₆ - Butachlor @ 0.75 kg a.i. ha⁻¹ (P.E.) + one hand weeding at 45 DAT, T₇ - Butachlor @ 0.75 kg a.i. ha⁻¹ + 2,4-D @ 0.5 Kg a.i. ha⁻¹ at 45 DAT, T₈ - Anilofos @ 0.5 kg a.i. ha⁻¹ P.E. + one hand weeding at 45 DAT and T₉ - Anilofos @ 0.5 kg ai ha⁻¹ (P.E.) + 2,4-D @ 0.5 Kg a.i. ha⁻¹ at 45 DAT (Post emergence) with each treatment replicated three times, resulting in a total of 27 plots. To maintain separation between replications, a gap of 1 meter was maintained. This experimental setup aimed to explore various aspects of rice growth and performance under different conditions and treatments. Composite soil sample was collected before to the experiment start from all three replications. It was found that the soil of experimental field was acidic in nature, low in organic carbon content and available phosphorous, medium in potassium and slightly deficient or low in available nitrogen. Harvesting is done when 90% of the grain population has turned yellow. In the harvesting process, it is important to carefully observe the level of maturity of the rice grains. Harvesting is done traditionally by cutting the stems of the rice plant and then the panicles are threshed and data processing in the study was carried out with the ANOVA test.

Results and Discussion

Weed count

Echinochloa colona

The data on effect of integrated weed management treatments on weed count (no. m⁻²) of *Echinochloa colona* in table 1 and illustrated in Fig1 shows that the lowest weed density was found in weed free (T₂) plot. Among the rest of the treatments, T₉ {Anilofos @ 0.5 kg ai ha⁻¹ (P.E.) + 2,4-D @ 0.5 Kg a.i. ha⁻¹ at 45 DAT (PoE)} also has the lowest population of *E. colona* which remains at par with weed free (T₂) due to the combined effect of pre- and post-emergence herbicides-controlled weeds at early as well as at later stages, preventing their survival and regrowth throughout the rice growth period. Whereas due to favorable growth conditions and reduced competition, *Colona spp.* prospers under weedy check plots (T₁) during the early stage of crop period but it declined towards maturity because of crop shading, resource competition, and completion of weed life cycles. These findings agree with Singh *et al.* (2005)^[25] and Mahajan *et al.* (2013)^[15] who reported that weedy check plots maintain the highest weed density throughout the crop season, whereas sequential herbicide applications—particularly pre-emergence followed by post-emergence treatments such as 2,4-

D-effectively suppress *Echinochloa colona* and keep weed populations comparable to weed-free conditions.

Commelina benghalensis

The data pertaining to effect of integrated weed management treatments on weed count (No. m⁻²) of *Commelina benghalensis* have been presented in the table 2 and Fig 2. The result indicated that the treatment T₁ (Weedy check plot) recorded the highest weed density at all stages, whereas treatment T₂ (Weed-free) maintained the lowest weed density throughout the rice crop growth period during investigation. Treatment T₅ (Pendimethalin @ 1.0 kg a.i. ha⁻¹ + 2,4-D @ 0.5 kg a.i. ha⁻¹ at 45 DAT) also recorded the lowest population of *Commelina benghalensis* which was statistically at par with the weed-free (T₂) due to the pendimethalin controlled weeds population at the sprouting stage, while 2,4-D controlled weeds that grew later, gives effective weed control for the whole crop season. However, the highest weed population was observed under the treatment T₁ (Weedy check) due to severe weed infestation under uncontrolled conditions. Rao and Nagamani. (2013) [21] who also stated that the sequential application of pre- and post-emergence herbicides significantly reduced weed density compared with single treatments and manual weeding, while weedy check plots consistently recorded the highest infestation. A similar trend was also observed by Chauhan *et al.* 2012 [9] and Upasani and Barla. (2014) [30].

Ageratum conyzoides

The data presented in table 3 and depicted in Fig 3 indicated that the effect of integrated weed management treatments on weed count (No. m⁻²) of *Ageratum conyzoides*. The T₁ (weedy check plots) recorded the highest weed density throughout the rice crop period due to heavy weed presence in the absence of weed control measures, whereas the T₂ (weed-free) maintained the lowest weed density at all stages because weeds were consistently controlled. Among the integrated weed management practices, the application of T₅ (Pendimethalin @ 1.0 kg a.i. ha⁻¹ + 2,4-D @ 0.5 kg a.i. ha⁻¹ at 45 DAT) recorded significantly lower weed density and remained at par with the T₂ (weed-free) treatment due to the pre-emergence application of pendimethalin *fb* post emergence application of 2,4-D provided better control of broad leaf weeds throughout the crop season. These findings are in conformity with Singh *et al.* (2013) [26] who reported that combined herbicide treatments significantly improved weed control compared to individual herbicides and untreated plots, reducing weed density in transplanting rice. The integrated herbicide programs significantly reduced weed density compared with single treatments (pendimethalin), whereas untreated plots consistently recorded the highest weed infestation. (Kumar *et al.* 2017) [12].

Digitaria sanguinalis

Among the data in table 4 and Fig 4 shows that the effect of integrated weed management treatments on weed count (No. m⁻²) of *Digitaria sanguinalis*. The T₂ (weed-free) maintained the lowest weed density throughout the investigation because weeds were removed regularly which preventing their growth and establishment. Among herbicidal treatments, the lowest weed density was recorded with T₈ (Anilofos @ 0.5 kg a.i. ha⁻¹ P.E.+ one hand weeding at 45 DAT) which was statistically at par with the T₂ (weed-free). Treatments involving pendimethalin or butachlor as pre-emergence followed by one hand weeding also effectively reduced weed density and were significantly superior to the weedy check, though they recorded relatively low weed

populations. Herbicide combinations with 2,4-D provided effective control but generally recorded slightly higher densities than their respective hand-weeding combinations, as *Digitaria sanguinalis* being a grassy weed, it is not effectively controlled by 2,4-D which primarily targets broadleaf species. Weedy check plots showed maximum *Digitaria sanguinalis* density, while integrated weed management treatments effectively suppressed it. The results were similar to study conducted by Naby and Ghandor (2022) [18] and found that sequential application of pre-emergence herbicides (e.g. pendimethalin) followed by post-emergence herbicides significantly reduced grassy weed density and improved weed control efficiency compared to single herbicide applications and untreated plots. These findings are also supported by Saha and Rao (2010).

Bidens pilosa

The data on effect of integrated weed management treatments on weed count (No. m⁻²) of *Bidens pilosa* have been presented in table 5 and graphically in fig 5. The maximum weed density was observed in the T₁ (weedy check) throughout the rice growth period, with a steady increase up to 150 DAT followed by a slight reduction at maturity, while the T₂ (weed-free) consistently recorded the minimum weed density. Among the rest of the treatments, the most effective control of *Biden pilosa* population was achieved with T₅ (Pendimethalin @ 1.0 kg a.i. ha⁻¹ + 2,4-D @ 0.5 kg a.i. ha⁻¹ at 45 DAT) which were statistically at par with the T₂ (Weed-free) particularly during the later growth stages. The use of pendimethalin @ 1.0 kg a.i. ha⁻¹, butachlor @ 0.75 kg a.i. ha⁻¹ or anilofos @ 0.5 kg a.i. ha⁻¹ as pre-emergence each supplemented with one hand weeding at 45 DAT resulted in moderate weed suppression and performed significantly better than the untreated control. The integrated herbicide treatments significantly reduced weed density compared with manual weeding, while untreated plots maintained the highest infestation. These findings agree with Angiras *et al.* (2006) [2], who reported moderate weed suppression when herbicides were combined with hand weeding, while untreated plots consistently showed maximum weed infestation throughout the crop season.

Other weeds count

The term other weed is used to denote the weeds occurring in the field other than *Echinochloa colona*, *Commelina benghalensis*, *Ageratum conyzoides*, *Digitaria sanguinalis* and *Biden pilosa*. The weed species such as *Aeschynomene indica*, *Cyperus rotundus* and *Persicaria hydropiper* were also present in very small number. The weed count was recorded and have been presented in table 6 and illustrated in Fig 6. The result indicated that the T₁ (weedy check) exhibited the maximum weed density throughout the crop growth period, showing an increasing trend up to 120–150 DAT followed by a marginal decline at maturity, whereas the weed-free treatment consistently maintained the minimum weed density across all stages. The T₂ (Weed-free) treatment consistently maintained the minimum weed density across all stages. The most effective weed suppression among herbicidal treatments was achieved with T₉ {Anilofos @ 0.5 kg a.i. ha⁻¹ (P.E.) + 2,4-D @ 0.5 kg a.i. ha⁻¹ at 45 DAT (PoE)} which was equivalent to the T₂ (Weed-free), particularly during the later stages of crop growth. Overall, *Aeschynomene indica* and *Persicaria hydropiper* belonging to the broadleaf weed category and these weeds were effectively controlled by 2,4-D, while pre-emergence herbicides like pendimethalin, butachlor, and anilofos provided moderate suppression at the seedling stage while *Cyperus rotundus* is a sedge and mainly controlled by pre-emergence herbicides, as

2,4-D is ineffective against sedges. Thus, combining pre and post emergence herbicides ensured season-long control of both broadleaf and grassy or sedge weeds, reducing overall weed density and competition. Similar findings were observed by Singh *et al.* (2007)^[25] and Kumar *et al.* (2025)^[14].

Total weed count (No. m⁻²), total weed dry weight (g m⁻²), weed control efficiency (%) and weed index (%).

Among the data in table 7 and Fig 7 shows the total weed count (No. m⁻²), total weed dry weight (g m⁻²), weed control efficiency (%) and weed index (%). The result indicated that the weed-free (T₂) treatment recorded the lowest total weed count, total weed dry weight and weed index because the weeds were removed at a proper interval of the time and indicating the significance of total weed control. Treatments T₆>T₈>T₄ showed comparatively higher values of total weed population and total weed dry weight because of partial control measures suppressed weeds moderately but did not fully prevent their growth and establishment the results show that T₁ (Weedy check) was the most prevalent treatment as it measures the highest dry weight of weeds and T₂ (Weed free) was the most successful in reducing the total weed dry weight during the experiment, highlighting why correct weed control matters. Proper weed management plays an important role in reducing weed density and minimizing crop–weed competition, as reported in earlier studies {Chauhan *et al.* (2006)^[9] Singh *et al.* (2017)}.

In case of weed control efficiency treatment T₁ (Weedy check plots), signifying the highest population of the weed and no control of weed during the investigation. Weed free plot (T₂) recorded the highest value of WCE (99.17) which was followed by T₉, T₇ and T₅ indicating stronger effectiveness of treatments in controlling the weeds in rice crop. Among the remaining treatments. The maximum weed control efficiency was observed when the field was kept weed free by continuous hand weeding and by application of pre and post emergence herbicides during the investigation as per the requirement, resulting in fewer weeds and less dry matter accumulation but in the harvest index that the weed-free (T₂) treatment recorded the lowest weed index because the weeds were removed at a proper interval of the time and indicating the significance of total weed control and whereas treatments T₅ followed by T₇>T₃>T₉ also showed lower weed index 6.49, 9.58, 15.09 and 17.52% due to successful weed suppression and decreased crop–weed competition under these treatments. On the other hand, the T₁ (Weedy check plot) had the highest weed index *i.e.* 41.82%, due to the non-removal of the weeds in the plot which significant yield losses from unregulated weed development. These results are consistent with Malik *et al.* (2012) supports that effective herbicide combinations result in lower weed index and reduced crop–weed competition.

Yield

Among the data in table 8 and depicted in Fig 8 show the effect

of different integrated weed management practices on grain yield (q ha⁻¹) and straw yield (q ha⁻¹), Biological yield (q ha⁻¹) and harvest index (%).

The findings demonstrated how different integrated weed control techniques affected grain and straw yields in quintals per hectare. Grain yield (48.51 q ha⁻¹), straw yield (66.94 q ha⁻¹) and biological yield (115.45 q ha⁻¹) was recorded considerably higher in treatment T₂ (weed-free check) than in the other treatments. The next best treatments were T₅ (Pendimethalin @ 1.0 kg a.i. ha⁻¹ + 2,4-D @ 0.5 kg a.i. ha⁻¹ at 45 DAT) and T₇ (Butachlor @ 0.75 kg a.i. ha⁻¹ + 2,4-D @ 0.5 kg a.i. ha⁻¹ at 45 DAT) both of which are statistically comparable to treatment T₂. Conversely, compared to the other treatments, treatment T₁ (Weedy check) showed the lowest grain, straw yield and biological yield. The highest HI was recorded in T₄ followed by T₉ and T₆ indicating better partitioning of assimilates towards grain under effective weed control. Temperate values were observed in the following manner T₃>T₈>T₇>T₅>T₁.

The lowest grain yield and straw yield was recorded under weedy check plots (T₁) due to higher infestation of weeds in the plots resulted in strong competition of weeds with the crop for various growth factors. Weedy check recorded the lowest yield due to the heavy weed infestation and more competition between the crop resulting in the low nutrient uptake by the crop, while weeds removed more quantity of nutrients throughout the crop growth period.

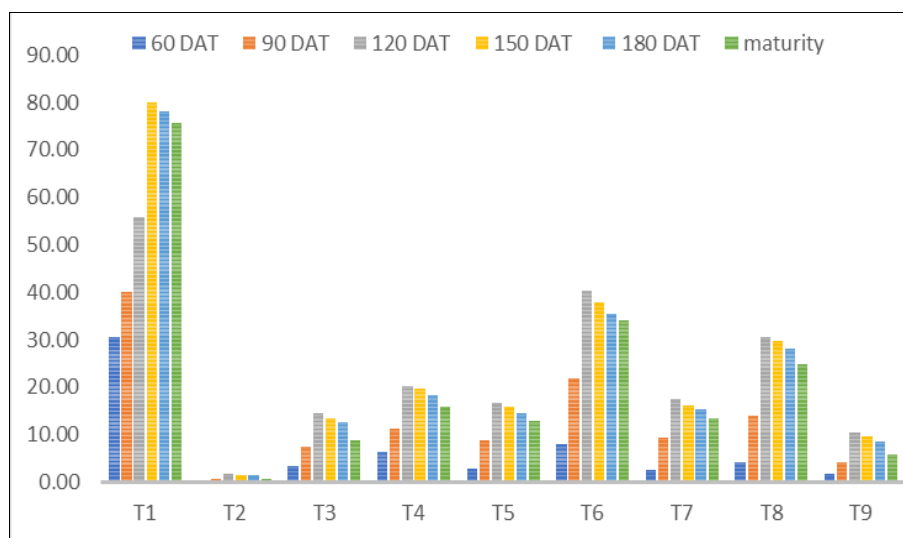
Meanwhile, higher grain and straw yield was recorded under weed-free plots (T₂) during the investigation mainly due to the lesser crop weed competition, higher weed free period. During investigation, the highest biological yield were recorded under the treatment T₂ (weed free plot) due to frequent elimination of weeds that resulted in the reduced weed competition, required particularly at most rapid tillering stage of rice whereas, the lowest biological yield was recorded under weedy check plots because in the weedy check pot weeds are not controlled, they quickly use up soil nutrients like nitrogen and phosphorus, leaving less for the crop and resulting in weaker growth and lower the yield (Mann *et al.* 2007 and Yadav *et al.* 2007)^[16, 31]. The IWM techniques limited weed infestation, maximized crop establishment, and decreased weed competition, they produced the best grain production. Crop growth and health were promoted by weed control measures, which reduced weed dry matter buildup and improved nutrient absorption. Crop losses were decreased by prompt weed control, which stopped extended weed competition. Similar findings were also reported by is supported by Rao *et al.* (2008)^[20], Bajwa *et al.* (2018)^[7], Shahzad *et al.* (2012)^[23] and Kumar *et al.* (2016)^[13], who reported that effective weed management enhances biomass and yield, whereas severe weed competition significantly reduces crop growth and yield.

Table 1: Effect of integrated weed management treatments on weed count (No. m⁻²) of *Echinochloa colona*

Sr. no.	Treatment Details	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT	Maturity
T ₁	Weedy check	5.57 (30.51)	6.37 (40.09)	7.45 (55.93)	8.97 (80.17)	8.85 (78.04)	8.73 (75.70)
T ₂	Weed free	0.77 (0.10)	1.13 (0.79)	1.48 (1.75)	1.43 (1.60)	1.40 (1.50)	1.14 (0.80)
T ₃	2 hand weeding at 10 DAT & 45 DAT	1.96 (3.48)	2.82 (7.48)	3.82 (14.48)	3.66 (13.40)	3.60 (12.69)	3.01 (8.81)
T ₄	Pendimethalin @ 1.0 kg a.i. ha ⁻¹ (pre- emergence) + one hand weeding at 45 DAT	2.60 (6.40)	3.43 (11.38)	4.44 (20.34)	4.41 (19.68)	4.22 (18.41)	3.92 (15.90)
T ₅	Pendimethalin @ 1.0 kg a.i. ha ⁻¹ + 2,4-D @ 0.5 kg a.i. ha ⁻¹ at 45 DAT	1.80 (2.84)	3.04 (8.79)	4.09 (16.63)	4.02 (15.78)	3.84 (14.66)	3.61 (12.86)

T ₆	Butachlor @ 0.75 kg a.i. ha ⁻¹ (P.E.) + one hand weeding at 45 DAT	2.92 (8.10)	4.62 (21.78)	6.37 (40.39)	6.13 (38.03)	5.94 (35.33)	5.85 (33.99)
T ₇	Butachlor @ 0.75 kg a.i. ha ⁻¹ + 2,4-D @ 0.5 Kg a.i. ha ⁻¹ at 45 DAT	1.70 (2.48)	3.11 (9.24)	4.20 (17.54)	4.11 (16.27)	3.93 (15.32)	3.70 (13.47)
T ₈	Anilofos @ 0.5 kg a.i. ha ⁻¹ P.E. + one hand weeding at 45 DAT	2.17 (4.23)	3.80 (13.92)	5.44 (30.55)	5.40 (29.64)	5.22 (28.05)	4.91 (24.96)
T ₉	Anilofos @ 05 kg ai ha ⁻¹ (P.E.) + 2,4-D @ 0.5 Kg a.i. ha ⁻¹ at 45 DAT (Post emergence)	1.47 (1.74)	2.14 (4.12)	3.28 (10.54)	3.13 (9.58)	2.94 (8.47)	2.46 (5.91)
SEm ±		15.04	26.37	20.54	21.04	22.79	16.83
CD(P)=0.05		1.73	5.96	9.02	9.07	9.31	6.84

(values in parentheses are means of original values)

**Fig 1:** Effect of integrated weed management treatments on weed count (No. m⁻²) of *Echinochloa colona***Table 2:** Effect of integrated weed management treatments on weed count (No. m⁻²) of *Commelina benghalensis*

Sr. no.	Treatment Details	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT	Maturity
T ₁	Weedy check	4.54 (20.12)	5.74 (32.51)	6.70 (44.47)	7.53 (56.26)	7.32 (54.26)	7.19 (51.21)
T ₂	Weed free	0.80 (0.14)	0.89 (0.30)	1.06 (0.65)	1.30 (1.22)	1.21 (0.99)	1.11 (0.75)
T ₃	2 hand weeding at 10 DAT & 45 DAT	1.80 (2.81)	2.23 (4.49)	2.84 (7.58)	3.25 (10.07)	3.10 (9.13)	2.77 (7.22)
T ₄	Pendimethalin @ 1.0 kg a.i. ha ⁻¹ (pre- emergence) + one hand weeding at 45 DAT	3.27 (10.24)	3.88 (14.55)	4.10 (16.45)	4.83 (22.63)	4.63 (21.15)	4.43 (19.14)
T ₅	Pendimethalin @ 1.0 kg a.i. ha ⁻¹ + 2,4-D @ 0.5 kg a.i. ha ⁻¹ at 45 DAT	1.51 (1.92)	1.82 (2.90)	2.15 (4.19)	2.62 (6.46)	2.45 (5.57)	1.90 (3.46)
T ₆	Butachlor @ 0.75 kg a.i. ha ⁻¹ (P.E.) + one hand weeding at 45 DAT	3.55 (12.10)	3.97 (15.28)	4.48 (19.70)	5.04 (25.30)	4.93 (24.15)	4.47 (19.50)
T ₇	Butachlor @ 0.75 kg a.i. ha ⁻¹ + 2,4-D @ 0.5 Kg a.i. ha ⁻¹ at 45 DAT	1.44 (1.68)	1.62 (2.17)	2.23 (4.50)	2.85 (7.65)	2.61 (6.33)	2.16 (4.28)
T ₈	Anilofos @ 0.5 kg a.i. ha ⁻¹ P.E. + one hand weeding at 45 DAT	3.98 (15.33)	4.5 (19.78)	4.98 (24.30)	5.56 (30.64)	5.40 (28.79)	4.99 (24.42)
T ₉	Anilofos @ 05 kg ai ha ⁻¹ (P.E.) + 2,4-D @ 0.5 Kg a.i. ha ⁻¹ at 45 DAT (Post emergence)	1.56 (2.10)	2.22 (4.45)	2.59 (6.34)	3.02 (8.66)	2.92 (7.89)	2.52 (5.75)
SEm ±		13.54	11.56	14.58	16.99	16.36	11.17
CD(P)=0.05		1.73	2.14	3.60	5.52	4.98	2.92

(values in parentheses are means of original values)

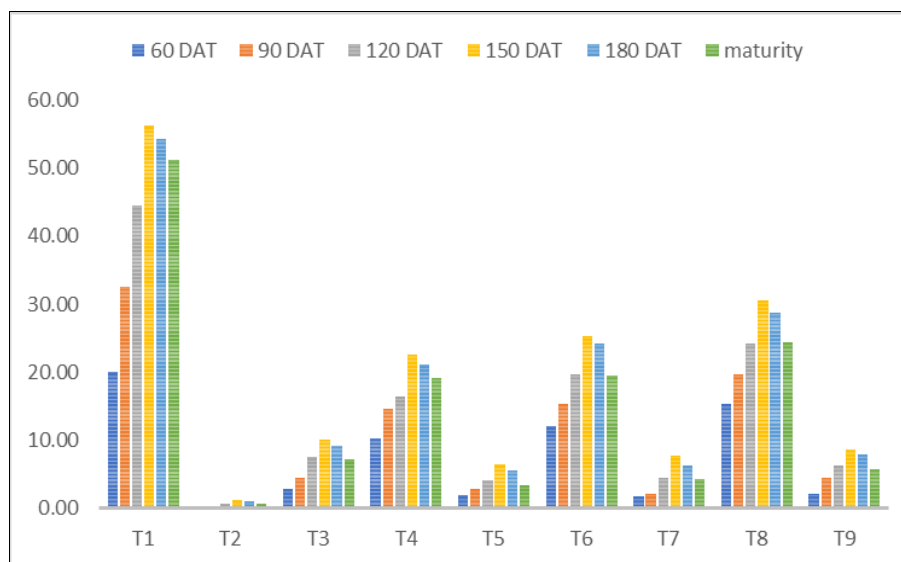


Fig 2: Effect of integrated weed management treatments on weed count (No. m⁻²) of *Commelina benghalensis*

Table 3: Effect of integrated weed management treatments on weed count (No. m⁻²) of *Ageratum conyzoides*

Sr. no.	Treatment Details	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT	Maturity
T ₁	Weedy check	4.56 (20.27)	6.71 (44.63)	7.84 (60.97)	7.66 (58.22)	7.49 (55.59)	7.27 (52.41)
T ₂	Weed free	0.84 (0.20)	1.10 (0.72)	1.28 (1.15)	1.14 (0.82)	1.02 (0.57)	0.94 (0.38)
T ₃	2 hand weeding at 10 DAT & 45 DAT	2.09 (4.14)	3.47 (11.64)	4.18 (16.94)	3.82 (14.13)	3.61 (12.54)	3.37 (10.95)
T ₄	Pendimethalin @ 1.0 kg a.i. ha ⁻¹ (pre- emergence) + one hand weeding at 45 DAT	3.62 (12.58)	5.05 (25.18)	5.75 (32.57)	5.55 (30.32)	5.33 (27.98)	4.98 (24.32)
T ₅	Pendimethalin @ 1.0 kg a.i. ha ⁻¹ + 2,4-D @ 0.5 kg a.i. ha ⁻¹ at 45 DAT	1.28 (1.22)	2.42 (5.76)	2.91 (7.98)	2.62 (6.49)	2.16 (4.31)	1.72 (2.52)
T ₆	Butachlor @ 0.75 kg a.i. ha ⁻¹ (P.E.) + one hand weeding at 45 DAT	3.99 (15.43)	5.04 (24.96)	5.52 (30.13)	5.38 (28.79)	5.06 (25.11)	4.78 (22.39)
T ₇	Butachlor @ 0.75 kg a.i. ha ⁻¹ + 2,4-D @ 0.5 Kg a.i. ha ⁻¹ at 45 DAT	1.73 (2.54)	2.88 (7.89)	3.30 (10.41)	3.14 (9.34)	2.83 (7.64)	2.41 (5.36)
T ₈	Anilofos @ 0.5 kg a.i. ha ⁻¹ P.E. + one hand weeding at 45 DAT	3.29 (10.33)	4.64 (21.09)	5.15 (26.70)	5.04 (25.38)	4.68 (22.25)	4.45 (19.47)
T ₉	Anilofos @ 05 kg ai ha ⁻¹ (P.E.) + 2,4-D @ 0.5 Kg a.i. ha ⁻¹ at 45 DAT (Post emergence)	1.88 (3.14)	3.02 (8.63)	3.54 (12.08)	3.45 (11.26)	3.14 (9.38)	2.76 (7.16)
SEm ±		15.16	17.68	18.26	20.05	19.21	16.21
CD(P)=0.05		2.04	5.12	6.99	7.12	6.11	4.52

(values in parentheses are means of original values)

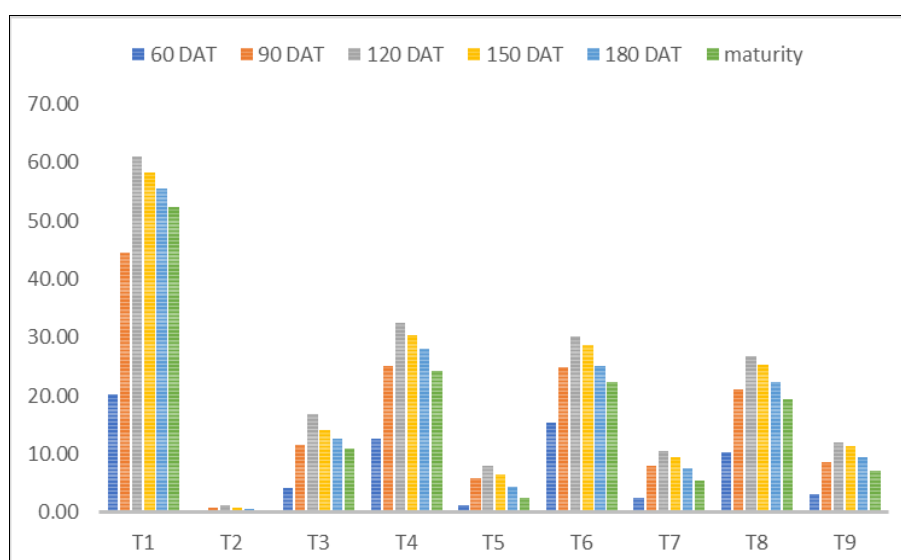
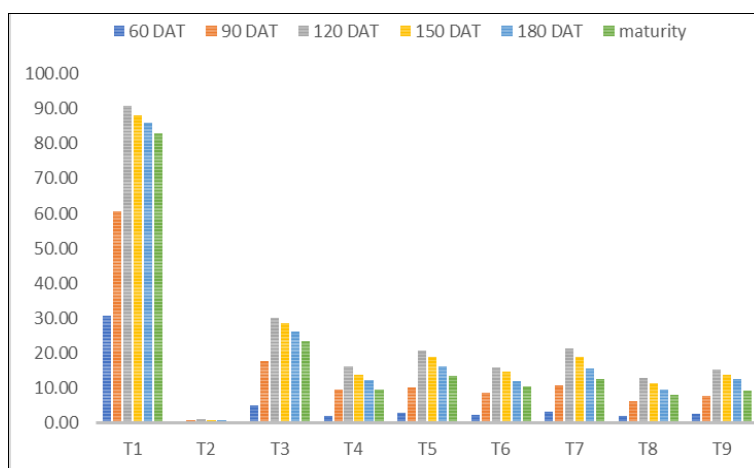


Table 3: Effect of integrated weed management treatments on weed count (No. m⁻²) of *Ageratum Conyzoides*

Table 4: Effect of integrated weed management treatments on weed count (No. m⁻²) of *Digitaria sanguinalis*

Sr. no.	Treatment Details	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT	Maturity
T ₁	Weedy check	5.60 (30.84)	7.80 (60.52)	9.53 (90.70)	9.39 (88.04)	9.28 (85.93)	9.12 (82.93)
T ₂	Weed free	0.86 (0.25)	1.11 (0.75)	1.27 (1.13)	1.19 (0.93)	1.09 (0.70)	1.02 (0.55)
T ₃	2 hand weeding at 10 DAT & 45 DAT	2.37 (5.14)	4.25 (17.79)	5.48 (30.19)	5.32 (28.69)	5.12 (26.27)	4.85 (23.56)
T ₄	Pendimethalin @ 1.0 kg a.i. ha ⁻¹ (pre- emergence) + one hand weeding at 45 DAT	1.56 (2.09)	3.09 (9.55)	4.04 (16.08)	3.74 (13.79)	3.55 (12.38)	3.17 (9.71)
T ₅	Pendimethalin @ 1.0 kg a.i. ha ⁻¹ + 2,4-D @ 0.5 kg a.i. ha ⁻¹ at 45 DAT	1.80 (2.81)	3.21 (10.20)	4.53 (20.60)	4.34 (18.85)	4.06 (16.37)	3.73 (13.61)
T ₆	Butachlor @ 0.75 kg a.i. ha ⁻¹ (P.E.) + one hand weeding at 45 DAT	1.64 (2.22)	3.02 (8.57)	4.02 (15.96)	3.85 (14.67)	3.54 (12.09)	3.30 (10.42)
T ₇	Butachlor @ 0.75 kg a.i. ha ⁻¹ + 2,4-D @ 0.5 Kg a.i. ha ⁻¹ at 45 DAT	1.90 (3.21)	3.26 (10.79)	4.66 (21.27)	4.37 (18.82)	3.99 (15.47)	3.60 (12.66)
T ₈	Anilofos @ 0.5 kg a.i. ha ⁻¹ P.E. + one hand weeding at 45 DAT	1.52 (1.95)	2.59 (6.36)	3.62 (12.75)	3.43 (11.44)	3.13 (9.64)	2.87 (7.95)
T ₉	Anilofos @ 05 kg ai ha ⁻¹ (P.E.) + 2,4-D @ 0.5 Kg a.i. ha ⁻¹ at 45 DAT (Post emergence)	1.75 (2.67)	2.84 (7.82)	3.88 (15.27)	3.71 (13.87)	3.49 (12.62)	3.09 (9.32)
SEm ±		17.68	23.08	27.97	31.48	29.27	24.98
CD(P)=0.05		1.74	5.88	12.05	12.66	10.78	8.20

(values in parentheses are means of original values)

**Fig 4:** Effect of integrated weed management treatments on weed count (No. m⁻²) of *Digitaria sanguinalis***Table 5:** Effect of integrated weed management treatments on weed count (No. m⁻²) of *Bidens Pilosa*

Sr. no.	Treatment Details	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT	Maturity
T ₁	Weedy check	5.55 (30.27)	6.80 (45.53)	7.83 (60.93)	8.97 (80.07)	8.87 (78.39)	8.65 (74.52)
T ₂	Weed free	0.81 (0.15)	0.89 (0.30)	1.05 (0.60)	1.29 (1.18)	1.16 (0.85)	1.05 (0.60)
T ₃	2 hand weeding at 10 DAT & 45 DAT	1.80 (2.81)	2.35 (5.11)	2.82 (7.51)	3.36 (10.87)	3.13 (9.41)	2.84 (7.66)
T ₄	Pendimethalin @ 1.0 kg a.i. ha ⁻¹ (pre- emergence) + one hand weeding at 45 DAT	3.28 (10.24)	4.10 (16.45)	4.87 (23.84)	5.50 (30.15)	5.36 (28.55)	5.10 (25.77)
T ₅	Pendimethalin @ 1.0 kg a.i. ha ⁻¹ + 2,4-D @ 0.5 kg a.i. ha ⁻¹ at 45 DAT	1.40 (1.67)	2.04 (3.86)	2.52 (6.06)	3.12 (9.52)	3.00 (8.80)	2.58 (6.46)
T ₆	Butachlor @ 0.75 kg a.i. ha ⁻¹ (P.E.) + one hand weeding at 45 DAT	3.70 (13.29)	4.48 (19.61)	5.22 (26.90)	5.93 (35.13)	5.80 (33.45)	5.57 (30.74)
T ₇	Butachlor @ 0.75 kg a.i. ha ⁻¹ + 2,4-D @ 0.5 Kg a.i. ha ⁻¹ at 45 DAT	1.90 (3.19)	2.40 (5.56)	3.02 (8.78)	3.41 (11.38)	3.15 (9.70)	2.74 (7.27)
T ₈	Anilofos @ 0.5 kg a.i. ha ⁻¹ P.E. + one hand weeding at 45 DAT	3.28 (10.48)	3.90 (14.75)	4.42 (19.22)	5.13 (25.82)	4.85 (23.11)	4.57 (20.64)
T ₉	Anilofos @ 05 kg ai ha ⁻¹ (P.E.) + 2,4-D @ 0.5 Kg a.i. ha ⁻¹ at 45 DAT (Post emergence)	1.78 (2.80)	2.15 (4.22)	2.69 (6.84)	3.02 (8.76)	2.78 (7.37)	2.43 (5.65)
SEm ±		15.31	16.99	17.88	18.98	19.08	15.24
CD(P)=0.05		2.21	3.77	5.53	7.77	7.33	5.26

(values in parentheses are means of original values)

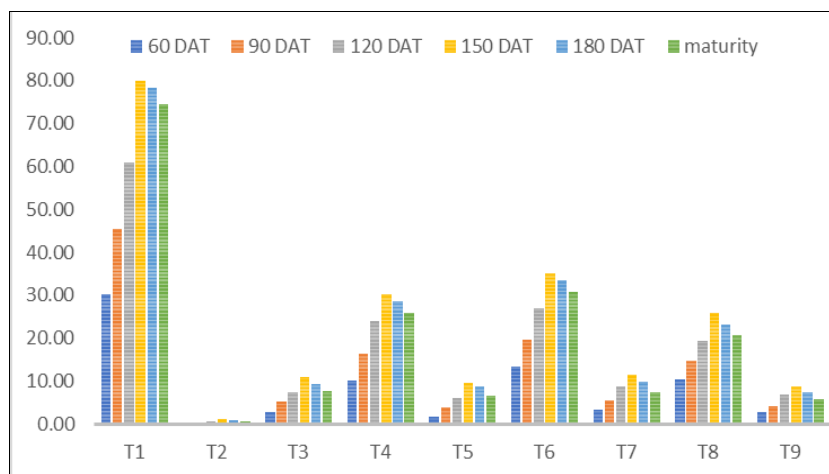


Fig 5: Effect of integrated weed management treatments on weed count (No. m⁻²) of *Bidens pilosa*

Table 6: Effect of integrated weed management treatments on weed count (No. m⁻²) of other weeds count

Sr. no.	Treatment Details	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT	Maturity
T ₁	Weedy check	3.57 (12.29)	4.36 (18.50)	5.06 (25.71)	4.90 (24.09)	4.76 (22.61)	4.37 (19.13)
T ₂	Weed free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
T ₃	2 hand weeding at 10 DAT & 45 DAT	2.06 (3.81)	2.29 (4.99)	3.00 (8.53)	2.78 (7.28)	2.50 (5.88)	2.15 (4.29)
T ₄	Pendimethalin @ 1.0 kg a.i. ha ⁻¹ (pre- emergence) + one hand weeding at 45 DAT	2.45 (5.54)	3.09 (9.22)	3.89 (14.81)	3.66 (13.17)	3.46 (11.80)	3.07 (9.06)
T ₅	Pendimethalin @ 1.0 kg a.i. ha ⁻¹ + 2,4-D @ 0.5 kg a.i. ha ⁻¹ at 45 DAT	1.60 (2.17)	2.62 (6.54)	3.12 (9.69)	2.89 (8.33)	2.69 (7.21)	2.39 (5.54)
T ₆	Butachlor @ 0.75 kg a.i. ha ⁻¹ (P.E.) + one hand weeding at 45 DAT	2.30 (4.89)	3.05 (8.86)	3.73 (13.63)	3.63 (12.81)	3.28 (10.39)	3.05 (8.91)
T ₇	Butachlor @ 0.75 kg a.i. ha ⁻¹ + 2,4-D @ 0.5 Kg a.i. ha ⁻¹ at 45 DAT	1.44 (1.64)	2.19 (4.33)	2.56 (6.27)	2.44 (5.60)	2.20 (4.45)	1.84 (2.97)
T ₈	Anilofos @ 0.5 kg a.i. ha ⁻¹ P.E. + one hand weeding at 45 DAT	2.62 (6.40)	2.84 (7.77)	3.52 (12.08)	3.44 (11.39)	3.19 (9.78)	2.77 (7.22)
T ₉	Anilofos @ 05 kg ai ha ⁻¹ (P.E.) + 2,4-D @ 0.5 Kg a.i. ha ⁻¹ at 45 DAT (Post emergence)	1.22 (0.98)	1.90 (3.19)	2.76 (7.44)	2.62 (6.62)	2.41 (5.62)	2.13 (4.25)
SEm ±		18.07	30.62	34.05	35.27	36.20	33.50
CD(P)=0.05		1.31	3.73	6.43	6.06	5.41	3.95

(values in parentheses are means of original values)

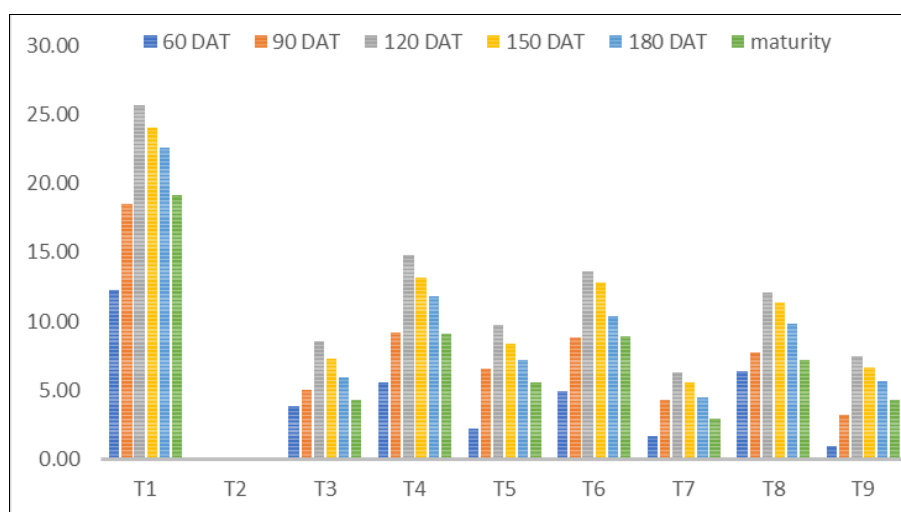
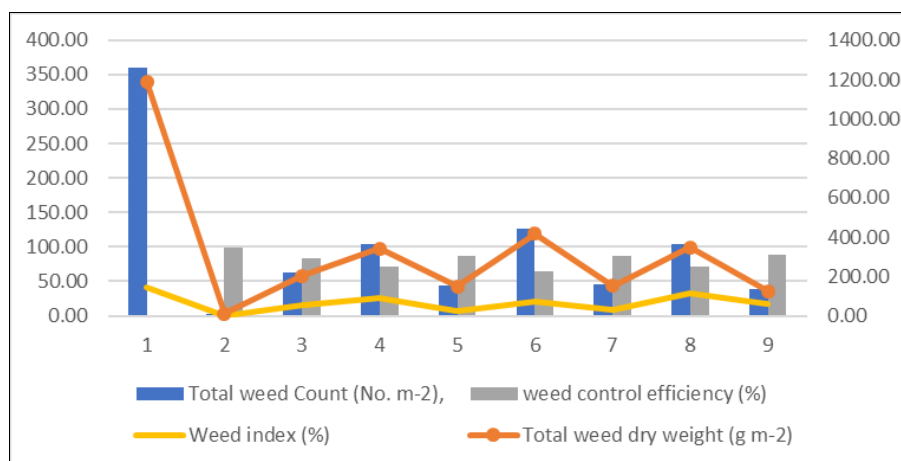


Fig 6: Effect of integrated weed management treatments on weed count (No. m⁻²) of other weeds count

Table 7: Effect of integrated weed management treatments on weed count (No. m⁻²) of total weed count (No. m⁻²), total weed dry weight (g m⁻²), weed control efficiency (%) and weed index (%).

Sr. no.	Treatment Details	Total weed count (No. m ⁻²)	Total weed dry weight (g m ⁻²)	Weed control efficiency (%)	Weed Index (%)
T ₁	Weedy check	19.00 (360.41)	34.54 (1188.00)	0	41.82
T ₂	Weed free	1.79 (3.09)	3.80 (9.90)	99.17	0
T ₃	2 hand weeding at 10 DAT & 45 DAT	7.92 (62.49)	14.45 (204.60)	82.78	15.09
T ₄	Pendimethalin @ 1.0 kg a.i. ha ⁻¹ (pre- emergence) + one hand weeding at 45 DAT	10.21 (103.90)	18.65 (343.20)	71.11	26.59
T ₅	Pendimethalin @ 1.0 kg a.i. ha ⁻¹ + 2,4-D @ 0.5 kg a.i. ha ⁻¹ at 45 DAT	6.68 (44.58)	12.37 (148.50)	87.5	6.49
T ₆	Butachlor @ 0.75 kg a.i. ha ⁻¹ (P.E.) + one hand weeding at 45 DAT	11.23 (125.94)	20.51 (415.80)	64.99	20.57
T ₇	Butachlor @ 0.75 kg a.i. ha ⁻¹ + 2,4-D @ 0.5 Kg a.i. ha ⁻¹ at 45 DAT	6.76 (46.00)	12.51 (151.80)	87.22	9.58
T ₈	Anilofos @ 0.5 kg a.i. ha ⁻¹ P.E. + one hand weeding at 45 DAT	10.24 (104.67)	18.74 (346.50)	70.83	33.14
T ₉	Anilofos @ 05 kg ai ha ⁻¹ (P.E.) + 2,4-D @ 0.5 Kg a.i. ha ⁻¹ at 45 DAT (Post emergence)	6.16 (38.04)	11.40 (125.40)	89.45	17.52
	SEm ±	4.99	2.61	---	---
	CD(P)=0.05	8.54	14.70	---	---

(values in parentheses are means of original values)

**Fig 7:** Effect of integrated weed management treatments on weed count (No. m⁻²) of total weed count (No. m⁻²), total weed dry weight (g m⁻²), weed control efficiency (%) and weed index (%).**Table 8:** Effect of different integrated weed management practices on grain yield (q ha⁻¹) and straw yield (q ha⁻¹), Biological yield (q ha⁻¹) and harvest index (%).

Sr. no.	Treatment Details	(q ha ⁻¹)			Harvest index (%)
		Grain Yield	Straw Yield	Biological yield	
T ₁	Weedy check	28.22	40.07	68.29	41.33
T ₂	Weed free	48.51	66.94	115.45	42.02
T ₃	2 hand weeding at 10 DAT & 45 DAT	41.19	55.61	96.80	42.56
T ₄	Pendimethalin @ 1.0 kg a.i. ha ⁻¹ (pre- emergence) + one hand weeding at 45 DAT	35.61	47.36	82.97	42.92
T ₅	Pendimethalin @ 1.0 kg a.i. ha ⁻¹ + 2,4-D @ 0.5 kg a.i. ha ⁻¹ at 45 DAT	45.36	62.14	107.50	42.20
T ₆	Butachlor @ 0.75 kg a.i. ha ⁻¹ (P.E.) + one hand weeding at 45 DAT	38.53	51.63	90.16	42.73
T ₇	Butachlor @ 0.75 kg a.i. ha ⁻¹ + 2,4-D @ 0.5 Kg a.i. ha ⁻¹ at 45 DAT	43.86	59.65	103.51	42.37
T ₈	Anilofos @ 0.5 kg a.i. ha ⁻¹ P.E. + one hand weeding at 45 DAT	32.43	43.13	75.56	42.55
T ₉	Anilofos @ 05 kg ai ha ⁻¹ (P.E.) + 2,4-D @ 0.5 Kg a.i. ha ⁻¹ at 45 DAT (Post emergence)	40.01	53.61	93.62	42.74
	SEm ±	9.09	11.55	68.29	41.33
	CD(P)=0.05	6.19	10.67	115.45	42.02

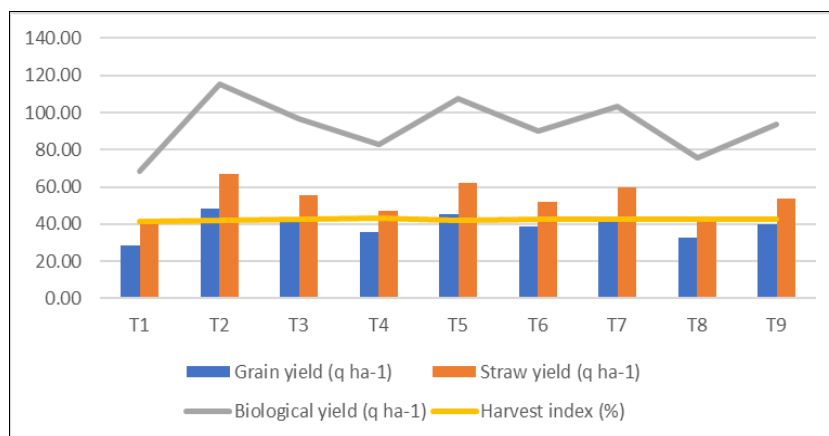


Fig 8: Effect of different integrated weed management practices on grain yield (q ha⁻¹) and straw yield (q ha⁻¹), Biological yield (q ha⁻¹) and harvest index (%).

Conclusion

In rice crop, weeds are among the major pests that can cause significant yield losses by competing with the crop for water, light, space, and nutrients. Treatment T₂ (Weed free) resulted in significantly lowest weed density of weed count and total weed dry weight (g m⁻²) along with a marked rise in weed control efficiency (WCE) by reducing the weed index {0} resulted in effective suppression of weeds led to overall increase in yield as compared to the rest of the treatments. The herbicide application of T₅ - Pendimethalin @ 1.0 kg a.i. ha⁻¹ + 2,4-D @ 0.5 kg a.i. ha⁻¹ at 45 DAT and T₇ - Butachlor @ 0.75 kg a.i. ha⁻¹ + 2,4-D @ 0.5 Kg a.i. ha⁻¹ at 45 DAT and were found to be superior treatments next to the T₂ (Weed free) in controlling weeds, improving growth and yield attributes and ultimately higher grain and straw yields of transplanted rice.

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