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Harnessing Integrated Weed Management for Sustainable Okra Cultivation: Synergizing Herbicides, Mechanical Weeding, and Mulching

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ABSTRACT

Okra (Abelmoschus esculentus), a vital vegetable in tropical and subtropical regions, faces intense weed competition due to its sluggish early development and open canopy, particularly during the rainy season. This study evaluates the effectiveness of integrated weed management (IWM) strategies in kharif okra, focusing on chemical, mechanical, and physical control methods. The experiment compared various treatments, including the use of herbicides (oxyfluorfen and propaquizafop), intercultivation, and black polythene mulch. Results demonstrated that combining oxyfluorfen and propaquizafop with intercultivation provided effective early-stage weed control. Meanwhile, mechanical weeding combined with hand weeding at critical stages reduced weed infestation and biomass significantly. Notably, black polythene mulch consistently achieved the highest weed control efficiency (WCE) throughout the crop cycle by acting as a physical barrier, suppressing light, and moderating soil temperature and moisture. One challenge faced in the study was the management of weed flushes at different crop stages, especially in high rainfall conditions that favored rapid weed proliferation. Additionally, the risk of phytotoxicity from certain herbicides necessitated precise application and timing. Despite these constraints, the study contributes valuable insights into practical, sustainable, and resource efficient weed control strategies for okra cultivation under monsoonal agroecosystems. This research confirms that a multi-strategy weed management approach especially the integration of plastic mulching with manual weeding offers a reliable and environmentally friendly method to optimize okra productivity in resource-constrained farming systems. The findings endorse IWM as a cornerstone for enhancing crop yield and sustainability in vegetable production.

Keywords: *Okra, Integrated Weed Management (IWM), Oxyfluorfen, Propaquizafop, Black Polythene Mulch, Weed Control Efficiency (WCE), Weed Index (WI), Weed Dynamics, Weed competition*

1. Introduction

Okra (*Abelmoschus esculentus*), a significant vegetable native to tropical regions and a member of the Malvaceae family, is widely cultivated during the kharif season in India and other tropical countries due to its high market demand and adaptability to warm, humid conditions. Characterized by a diploid chromosome number of 2n = 130, okra thrives in subtropical climates and is known for its nutritional richness, particularly its content of vitamins, iodine, dietary fiber, and mucilage [16]. India ranks as the largest producer of okra globally, accounting for over 70% of the world's output, with a substantial portion of the crop grown during the monsoon period [1].

Despite its agronomic potential, okra's early vegetative phase is marked by slow growth and limited canopy spread, making it highly vulnerable to weed competition, especially during the rainy season when weed seed banks proliferate rapidly. Weeds emerge concurrently with the crop and compete aggressively for critical growth resources, such as water, nutrients, light, and space, often surpassing the crop in growth rate and biomass accumulation. Additionally, weeds harbor insect pests, pathogens, and allelopathic chemicals, all of which negatively affect okra growth and productivity [3] [17].

Investigations have revealed that uncontrolled weed infestations can reduce okra yields by 40% to 80%, especially under kharif conditions where high rainfall accelerates weed germination and growth [9]. Therefore, managing weed dynamics, which include weed emergence, density, biomass, and species composition, is essential for sustainable okra production. Effective weed management not only reduces weed-crop competition but also enhances nutrient uptake, pod quality, and soil health [25].

In recent years, integrated weed management (IWM) approaches have gained prominence for being both cost-effective and environmentally sustainable. Among these, black polythene mulching has emerged as a powerful tool for suppressing weeds without relying solely on herbicides. Acting as a physical barrier, it obstructs sunlight, inhibits weed germination, and alters the soil microenvironment to favor crop growth. Moreover, it contributes to soil moisture conservation, temperature regulation, and improved nutrient retention, all of

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which benefit crop performance during the kharif season [14] [11].

Given the increasing demand for sustainable weed control methods, the aim of this study was to examine the effect of various weed control strategies, including black polythene mulch, chemical herbicides, and manual interventions, on weed dynamics in kharif okra. The objective was to identify practices that not only control weeds efficiently but also support crop health, nutrient use efficiency, and yield performance under monsoonal cultivation conditions.

2. Materials and Methods

2.1 Research location and environmental factors

The on-field investigation was undertaken during the kharif season at the Postgraduate Research Farm, Division of Vegetable Science, College of Horticulture, Rajendranagar, Telangana, India. This location lies in the semi-arid tropics of South India, characterized by high relative humidity and mean annual rainfall ranging between 850–1000 mm, primarily occurring from June to September. The field plot had a soil with a sandy-loam texture with neutral pH and moderate nutrient status, indicating low nitrogen, moderate phosphorus, and elevated potassium levels.

2.2 Experimental Layout and Treatment Structure

A Randomized Block Design (RBD) was employed for the experiment, consisting of 12 unique weed management treatments, each replicated thrice. A total of 36 plots were established, with uniform plot size and spacing. The treatment plan integrated chemical, mechanical, and mulching methods to evaluate their individual and combined impact on weed suppression and crop response.

Treatment Details:

✓ **T1:** Oxyfluorfen @ 0.2 kg/ha (pre-emergence) + propaquizafop @ 62.5 g/ha (post-emergence) + interculture at 45 DAS

✓ **T2:** Pendimethalin @ 675 g/ha (pre-emergence) + propaquizafop @ 62.5 g/ha (post-emergence) + interculture at 45 DAS

✓ **T3:** Oxadiargyl @ 90 g/ha (pre-emergence) + propaquizafop @ 62.5 g/ha (post-emergence) + interculture at 45 DAS

✓ **T4:** Oxyfluorfen + rice straw mulch applied at 7–10 DAS

✓ **T5:** Pendimethalin + rice straw mulch at 7–10 DAS

✓ **T6:** Oxadiargyl + rice straw mulch at 7–10 DAS

✓ **T7:** Rice straw mulch alone applied at 7–10 DAS

✓ **T8:** Black polythene mulch

✓ **T9:** Stale seedbed technique + intercropping with *Beta vulgaris* var. *palak*

✓ **T10:** Mechanical weeding at 15, 30, and 60 DAS

✓ **T11:** Mechanical weeding (inter-row) + hand weeding (intra-row) (Weed-free control)

✓ **T12:** Unweeded control

2.3 Crop Establishment and Nutrient Application

The crop variety used was Arka Anamika, sown with a 60 cm × 30 cm spacing. The field was ploughed thoroughly, and 25 tonnes/ha of well-decomposed FYM was incorporated before sowing. A consistent basal application of 40:60:60 kg/ha N:P: K was uniformly applied with urea, single superphosphate, and muriate of potash, respectively. Nitrogen was applied in two equal doses at 30 and 60 DAS as top dressing. A knapsack sprayer with flat fan nozzles was used to apply all herbicides, ensuring a spray volume of 500 liters per hectare.

2.4 Observations Recorded

Key observations were made on both weed and crop parameters at 30, 60, and 90 DAS. Weed assessments included:

- **Weed density (no./m^2)**
- **Weed dry weight (g/m^2)**
- **Weed control efficiency (WCE%)**
- **Weed index (WI%)**

Weed sampling was done using a 0.25 m^2 quadrat randomly placed in each plot. The collected weed samples were oven-dried at 65°C until a constant weight was achieved to measure dry matter. Weed counts and weights were later converted to per-square-meter equivalents. To achieve normal distribution, weed density and biomass data were transformed using the square root function, $\sqrt{(x + 0.5)}$, prior to statistical analysis.

2.5 Formulae Used

- **Weed Control Efficiency (WCE%)**

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

Where:

DMC = Weed dry matter in control plot (g/m^2)

DMT = Weed dry matter in treatment plot (g/m^2)

- **Weed Index (WI%)**

$$WI = \frac{Yf\text{-}Yt}{Yf} \times 100$$

Where:

Yf = Yield from weed-free plot (kg/ha)

Yt = Yield from treated plot (kg/ha)

2.6 Statistical Analysis

Analysis of Variance (ANOVA) for Randomized Block Design (RBD) was used to analyze the experimental data. Treatment means were evaluated using the Critical Difference (CD) for statistical significance at the 5% level. Graphs, including line charts with error bars, were generated using MS Excel and R software to illustrate NPK uptake by crop and removal by weeds.

3. Results and discussion

3.1 Weed Flora

During the experiment, the dominant weed species included a variety of grasses, sedges, and broad-leaved weeds (BLWs). The grasses *Cynodon dactylon* (L.) and *Dactyloctenium aegyptium* (L.) Beauv. Weeds were the most frequently encountered, which are known to be aggressive and competitive species in tropical cropping systems [18] [28]. *Cyperus rotundus* L. was the sole sedge species dominant across treatments, a species recognized for its persistence and underground tuber propagation in vegetable fields [29]. The BLW population was primarily composed of *Parthenium hysterophorus*, *Digera arvensis*, *Euphorbia hirta*, *Amaranthus viridis,* and *Commelina benghalensis*, a typical weed consortium in kharif-grown okra fields under Indian agro climatic conditions [2][6][21]. These species compete aggressively with okra for nutrients, light, and moisture during early growth stages, often leading to significant yield losses if unmanaged.

3.2 Weed Density

Significant variations in weed density were recorded across the different management treatments at 15, 30, 60, and 90 DAS (Table 3). At 15 DAS, the application of oxyfluorfen (0.2 kg ha^{1} PE) + propaquizafop (62.5 g ha^{1} PoE) + intercultivation at 45 DAS achieved the lowest total weed density, owing to the contact and residual effects of the herbicides. Oxyfluorfen effectively disrupts cell membranes in germinating weed seedlings, particularly targeting broad-leaved weeds (BLWs) by inhibiting protoporphyrinogen oxidase, a key enzyme in chlorophyll biosynthesis, thereby causing cell leakage and death [19] [8]. The combination with propaquizafop, a selective postemergence herbicide effective on grasses, enhances overall weed control efficiency during the early crop stages [20] [27].

By 30 and 60 DAS, mechanical inter-row weeding combined with intra-row hand weeding (weed-free check) proved highly effective in minimizing weed density. Timely physical removal of weeds at critical stages restricted their regrowth and competitive ability [10]. At 90 DAS, black polythene mulch significantly suppressed weed emergence and maintained the lowest weed density, statistically comparable to the weed-free check. The mulch likely prevented light penetration, inhibiting weed seed germination and acting as a physical barrier [26] [12].

3.3 Dry Weight of Weeds

Dry weed biomass was significantly influenced by the weed control treatments. At 15 DAS, the combination of oxyfluorfen + propaquizafop + intercultivation yielded the lowest dry weight due to early weed knockdown. However, mechanical + hand weeding at 30 and 60 DAS consistently reduced dry matter accumulation throughout mid-growth stages [24].

At 90 DAS, black polythene mulch recorded the lowest dry weight of weeds, closely followed by the weed-free check. This extended weed suppression is attributed to the mulch's ability to block sunlight, trap soil moisture, and physically hinder weed growth [22] [26]. Unweeded control plots consistently registered the highest dry weed biomass due to unchecked weed proliferation.

3.4 Weed Control Efficiency (WCE)

Weed control efficiency (WCE) was calculated based on the reduction in dry weed biomass compared to the unweeded control. The highest WCE at 15 DAS was recorded in oxyfluorfen + propaquizafop + intercultivation plots, indicating strong early-stage suppression [4]. At 30 and 60 DAS, WCE peaked in the weed-free check, followed closely by black polythene mulch, which maintained consistent suppression.

By 90 DAS, black polythene mulch emerged as the most effective treatment, achieving the highest WCE due to its prolonged impact and weed-smothering effect. These findings corroborate those of [7] [11], who reported sustained efficacy of plastic mulch over multiple crop stages.

3.5 Weed Index (WI)

Weed index values, which reflect yield loss due to weed competition, showed a clear trend. The weed-free check recorded the lowest WI, indicating maximum yield preservation through sustained weed suppression [15]. Black polythene mulch followed closely, benefiting from its ability to reduce weed competition and enhance crop performance.

In contrast, the unweeded control recorded the highest WI due to severe crop-weed competition. The data suggest that both mechanical weeding and black polythene mulching are effective in minimizing yield losses, with mulch offering additional benefits such as soil moisture retention and temperature moderation [26][12].

4. Discussion

Effective weed management is crucial in okra cultivation due to the crop's slow early growth and sparse canopy, which leaves it vulnerable to weed competition [22]. The study clearly demonstrates that both chemical and physical methods, when properly timed and combined, can significantly reduce weed pressure and improve crop performance.

The use of oxyfluorfen as a pre-emergence herbicide, in combination with post-emergence propaquizafop and intercultivation, proved effective at suppressing early-stage weeds, particularly grasses and broad-leaved weeds. This aligns with findings by [13], who reported that oxyfluorfen effectively controls germinating weed seedlings through membrane disruption. However, caution is needed with oxyfluorfen application as high doses may exhibit phytotoxic effects on okra [23].

Mechanical inter-row weeding combined with intra-row hand weeding, though labor-intensive, offered excellent control at 30 and 60 DAS. Its repeated use helped suppress successive flushes of weeds and minimized their competitive impact on the crop, confirming earlier reports by [10] that physical removal is highly effective when synchronized with weed emergence patterns.

Among all treatments, black polythene mulch consistently demonstrated strong weed suppression throughout the crop cycle. It physically blocked sunlight, reduced weed germination, and created a barrier to seedling emergence, particularly effective at later stages [26][12]. Moreover, mulching also helped retain soil moisture and maintain stable temperatures, indirectly benefiting okra growth. These multidimensional benefits have been emphasized in studies on plastic mulching in vegetable crops [5] [15].

Dry weed biomass trends mirrored those of weed density, with unweeded plots accumulating the highest dry matter. This indicates unchecked competition for nutrients, light, and moisture, ultimately reducing okra yield. On the other hand, black polythene mulch and the weed-free check significantly reduced dry matter accumulation, thus improving crop growth conditions [7].

Weed control efficiency (WCE) was highest in herbicide-based treatments during early growth stages but later declined due to new weed flushes. In contrast, black polythene mulch maintained a consistent WCE throughout, supporting its role in sustained weed suppression [22][26]. The low weed index observed in these treatments also reflects reduced yield losses due to lower weed pressure.

Overall, the findings reinforce the effectiveness of integrated weed management approaches that combine chemical, mechanical, and cultural methods. In particular, black polythene mulch and manual weeding strategies remain reliable options for resource-limited farmers seeking long-term weed control with minimal environmental impact [15][11].

Conclusion

The study highlights the critical role of effective weed management in optimizing okra (*Abelmoschus esculentus*) productivity. The results clearly demonstrate that a combination of chemical, mechanical, and physical methods can provide sustainable and efficient control of weed growth, leading to improved crop performance.

Among the treatments evaluated, the integration of oxyfluorfen as a pre-emergence herbicide combined with propaquizafop as a post-emergence herbicide, followed by intercultivation, proved to be effective in controlling weeds at early crop growth stages. However, the phytotoxic effects of oxyfluorfen on the crop necessitate careful application timing and dosage.

Mechanical methods, including inter-row and intra-row weeding, consistently demonstrated their efficacy at controlling weed density and dry weight, particularly when implemented at 30 and 60 DAS. These methods help to suppress weeds effectively during critical periods of growth, although they require significant labor input.

Black polythene mulch emerged as the most efficient treatment for sustained weed suppression across all growth stages, especially at 90 DAS. Its effectiveness can be attributed to its ability to block light, thus preventing weed seed germination and growth, while also offering added benefits such as moisture retention and temperature moderation.

Overall, integrated weed management approaches, combining herbicides, mechanical weeding, and plastic mulching, offer reliable and environmentally sustainable solutions for okra cultivation. These methods not only minimize weed competition but also enhance crop yield and quality. As such, these strategies are highly recommended for resource-limited farmers seeking long-term weed control while minimizing environmental impact.

Future Scope

Future research may focus on integrating organic mulches and bio-herbicides with mechanical and cultural methods to enhance sustainability and reduce chemical dependency. Additionally, evaluating the long-term effects of integrated weed management on soil health, weed seed bank dynamics, and crop quality under varying agro-climatic conditions would provide a more holistic understanding. Exploring cost-benefit analysis and farmer adoption behavior could further support large-scale implementation of these strategies.

Conflict of Interest

The authors declare no conflict of interest regarding the publication of this manuscript.

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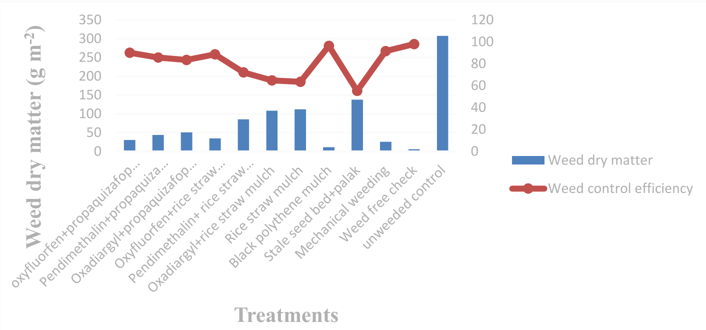

Fig 1: "Influence of different weed management practices on weed dry matter (g m-2) and weed control efficiency (%) at 30 DAYS"

Table 1: "Weed flora of the experimental field"

Sl. No	Scientific Name	Common Name	Family
A. Sedges			
1	*Cyperus rotundus* L.	Purple nutsedge, Nut grass, Coco grass	Cyperaceae
B. Grasses			
1	*Cynodon dactylon* (L.) Pers.	Bermuda grass, Star grass, Devils grass	Poaceae
2	*Dactyloctenium aegyptium* L.Beauv.	Crow foot grass	Poaceae
3	*Eleusine indica* (L.) Gaertn.	Goosegrass, Wire grass	Poaceae
4	*Digitaria sanguinalis* (L.) Scop.	Large crabgrass	Poaceae
5	*Poa annua* L.	Bluegrass / Wild buckwheat	Poaceae
C. Broad Leaved Weeds			
1	*Amaranthus viridis* L.	Slender pigweed	Amaranthaceae
2	*Digera arvensis* Forsk	Digera, Kondra	Amaranthaceae
3	*Achyranthes aspera* L.	Prickly chaff flower	Amaranthaceae
4	*Parthenium hysterophorus* L.	Congress grass/ Carrot grass / Ragweed	Compositae
5	*Sonchus oleraceus* L.	Annual sowthistle	Compositae
6	*Cleome viscosa* L.	Spider flower	Capparidaceae
7	*Tridax procumbens* L.	--	Compositaceae
8	*Euphorbia hirta* L.	Pillpod spurge, Garden spurge	Euphorbiaceae
9	*Phyllanthus niruri* L.	Niruri	Euphorbiaceae
10	*Portulaca oleracea* L.	Common purslane	Portulacaceae

11	*Argemone mexicana* L.	Mexican prickly poppy,	Papaveraceae
12	*Commelina benghalensis* L.	Bengal day flower	Commelinaceae
13	*Celosia argentea* var. *cristata*	Cockscomb	Amaranthaceae
14	*Trianthema portulacastrum* L.	Black pigweed	Aizoaceae
15	*Alternanthera sessilis* L.	Dwarf copperleaf	Amaranthaceae
16	*Boerhavia diffusa*	Red spiderling	Nyctaginaceae
17	*Convolvulus pluricaulis*	Asian pigeonwings	Convolvulaceae
18	*Senna auriculata* L.	Avaram senna	Fabaceae

Table 2: "Density of grasses, sedges, BLW and total weed density (number m^{-2}) as influenced by weed management practices in okra"

Treatment		Grasses (number m^{-2})				Sedges(number m^{-2})				BLW's(number m^{-2})				Total weed density (number m^{-2})			
		15 DAS	30 DAS	60 DAS	90 DAS	15 DAS	30 DAS	60 DAS	90 DAS	15 DAS	30 DAS	60 DAS	90 DAS	15 DAS	30 DAS	60 DAS	90 DAS
T_1	Oxyfluorfen 23.5% EC 0.2 kgha^{-1}(PE) *fb propaquizafop* 10% EC 62.5 gha^{-1} at 2-3 leaf stage (PoE)*fb intercultivation* at 45 DAS.	1.73^{a} (2.00)	2.13^{c} (4.06)	2.23^{b} (4.00)	2.45^{b} (5.00)	1.73^{a} (2.00)	2.71^{d} (6.33)	2.64^{b} (6.00)	3.14^{b} (9.00)	2.74^{a} (7.00)	4.34^{bc} (18.33)	3.81^{b} (14.00	4.38^{a} (18.66)	3.39^{a} (11.00)	5.40^{c} (28.72)	4.95^{ab} (24.00)	5.76^{b} (32.66)
T_2	Pendimethalin 38.7% CS 675 gha^{-1} (PE) *fb* propaquizafop 10% EC 62.5 gha^{-1} at 2-3 leaf stage (PoE) *fb* intercultivation at 45 DAS.	2.15^{b} (3.66)	3.05^{f} (4.31)	2.31^{bc} (4.33)	2.51^{b} (5.33)	2.08^{b} (3.33)	3.41^{fg} (10.66)	3.00^{c} (8.00)	3.31^{b} (10.00)	3.08^{ab} (9.00)	4.81^{c} (22.66)	4.34^{bc} (18.33)	5.49^{b} (29.66)	4.06^{b} (15.99)	6.17^{cd} (37.63)	5.58^{b} (30.66)	6.74^{c} (44.99)
T_3	Oxadiargyl 80% WP 90 gha^{-1} (PE) *fb propaquizafop* 10% EC 62.5 gha^{-1} at 2-3 leaf stage (PoE) *fb* intercultivation at 45 DAS.	2.23^{bc} (4.00)	2.23^{bc} (4.46)	2.37^{c} (4.66)	2.77^{c} (6.66)	2.15^{bc} (3.66)	3.51^{g} (11.33)	3.46^{d} (11.00)	4.50^{c} (19.33)	2.97^{a} (8.33)	5.02^{c} (24.66)	4.60^{c} (20.66)	5.84^{bc} (33.66)	4.06^{b} (15.99)	6.40^{d} (40.45)	6.07^{b} (36.32)	7.76^{d} (59.65)
T_4	Oxyfluorfen 23.5% EC 0.2 kgha^{-1} (PE) followed by rice straw mulch (5tha^{-1}) at 7-10 DAS.	1.82^{a} (2.33)	1.91^{bc} (2.66)	2.58^{cd} (5.66)	2.88^{c} (7.33)	1.91^{a} (2.66)	3.00^{e} (8.00)	4.08^{e} (15.66)	5.12^{d} (25.33)	3.14^{b} (9.33)	4.38^{b} (18.66)	5.55^{de} (30.33)	6.39^{cd} (40.33)	3.85^{ab} (14.32)	5.46^{c} (29.32)	7.22^{c} (51.65)	8.57^{e} (72.99)
T_5	Pendimethalin 38.7% CS 675 gha^{-1} *fb* rice straw mulch (5tha^{-1}) at 7-10 DAS.	2.51^{c} (5.33)	2.88^{ef} (7.33)	3.11^{e} (8.66)	3.32^{d} (10.00)	2.23^{c} (4.00)	3.70^{h} (12.66)	4.62^{g} (20.33)	5.38^{de} (28.00)	3.19^{b} (9.66)	5.18^{c} (26.33)	6.20^{ef} (38.00)	6.31^{c} (39.33)	4.41^{bc} (18.99)	6.84^{de} (46.32)	8.22^{de} (66.99)	8.82^{e} (77.33)
T_6	Oxadiargyl 80% WP 90 g ha^{-1}*fb* rice straw mulch (5t ha^{-1}) at 7-10 DAS	2.77^{cd} (6.66)	3.11^{f} (8.66)	2.71^{d} (6.33)	4.02^{fg} (15.66)	2.38^{cd} (4.66)	3.87^{i} (14.00)	4.43^{f} (18.66)	5.01^{d} (24.66)	3.29^{b} (10.33)	5.28^{c} (27.33)	5.70^{e} (32.00)	6.18^{c} (37.66)	4.71^{c} (21.65)	7.11^{e} (49.99)	7.58^{cd} (56.99)	8.86^{ef} (77.98)
T_7	Rice straw mulch at 7-10 DAS (5tha^{-1}).	2.82^{d} (7.00)	2.57^{d} (5.66)	3.65^{f} (12.33)	3.91^{f} (14.33)	2.45^{d} (5.00)	4.39^{jk} (18.33)	4.86^{h} (22.66)	5.47^{e} (29.00)	3.34^{b} (10.66)	6.10^{d} (36.66)	6.28^{f} (39.00)	6.79^{d} (45.66)	4.81^{c} (22.66)	7.82^{ef} (60.65)	8.63^{e} (73.99)	9.46^{f} (88.99)
T_8	Black polythene mulch.	2.15^{b} (3.66)	1.81^{b} (2.33)	2.08^{ab} (3.33)	2.15^{a} (3.66)	2.00^{b} (3.00)	1.82^{bc} (2.33)	2.31^{a} (4.33)	2.31^{a} (4.33)	3.08^{a} (9.00)	4.02^{b} (15.66)	3.89^{ab} (14.66)	4.14^{a} (16.66)	4.02^{b} (15.66)	4.56^{b} (20.32)	4.78^{a} (22.32)	5.01^{a} (24.65)
T_9	Stale seed bed followed by intercropping with green leafy vegetables (palak).	3.87^{fg} (14.46)	3.78^{g} (13.33)	3.21^{e} (9.33)	3.60^{e} (12.00)	3.32^{e} (10.54)	4.86^{k} (22.66)	5.32^{j} (27.33)	5.83^{e} (33.00)	4.71^{c} (21.65)	6.34^{d} (39.66)	6.60^{f} (43.00)	6.94^{de} (47.66)	6.87^{d} (46.65)	8.73^{f} (75.65)	8.55^{e} (72.66)	9.65^{f} (92.66)
T_{10}	Mechanical weeding at 15, 30, 60 DAS.	2.05^{b} (3.69)	3.11^{f} (8.66)	3.78^{f} (13.33)	4.20^{g} (16.68)	1.97^{b} (3.38)	1.96^{c} (3.33)	5.13^{i} (25.33)	5.65^{e} (31.00)	3.01^{a} (8.59)	3.58^{b} (12.33)	5.18^{d} (26.33)	6.99^{e} (48.33)	4.02^{b} (15.66)	4.98^{bc} (24.32)	8.09^{d} (64.99)	9.82^{f} (96.01)
T_{11}	Mechanical weeding (inter row) followed by hand weeding (intra row) at 30 and 60 DAS - (weed free check).	3.53^{e} (12.00)	1.35^{a} (1.33)	1.91^{a} (2.66)	2.31^{ab} (4.33)	4.87^{fg} (23.22)	1.47^{a} (1.66)	2.16^{a} (3.66)	2.88^{ab} (7.33)	5.96^{d} (35.00)	1.58^{a} (2.00)	3.76^{a} (13.66)	4.49^{a} (19.66)	8.40^{ef} (70.22)	2.34^{a} (4.99)	4.53^{a} (19.98)	5.64^{a} (31.32)
T_{12}	Unweeded Control	3.91^{g} (14.33)	5.00^{h} (24.00)	5.83^{g} (33.00)	6.51^{h} (41.33)	4.97^{g} (23.66)	5.57^{l} (30.00)	6.32^{k} (39.00)	6.53^{f} (41.66)	5.96^{d} (35.00)	7.99^{e} (63.33)	8.51^{g} (72.00)	9.01^{f} (80.66)	8.57^{f} (72.99)	10.85^{g} (117.33)	12.02^{f} (144.00)	12.81^{g} (163.65)
	SE (m)±	0.09	0.08	0.11	0.16	0.08	0.05	0.05	0.15	0.11	0.19	0.16	0.20	0.16	0.25	0.31	0.33
	CD at 5%	0.28	0.23	0.34	0.46	0.23	0.16	0.15	0.45	0.34	0.56	0.47	0.56	0.46	0.73	0.92	0.73

Table 3: "Weed dry matter (g m^{-2}), weed control efficiency (%) weed index (%) and total pod yield (t ha^{-1}) as influenced by weed management practices in okra"

Treatment		Weed dry matter (g m^{-2})				Weed control efficiency (%)				Weed index (%)
		15 DAS	30 DAS	60 DAS	90 DAS	15 DAS	30 DAS	60 DAS	90 DAS	
T_1	Oxyfluorfen 23.5% EC 0.2 kgha^{-1}(PE) *fb propaquizafop* 10% EC 62.5 gha^{-1} at 2-3 leaf stage (PoE)*fb intercultivation* at 45 DAS.	3.02^{a} (8.10)	5.63^{d} (30.73)	5.45^{b} (28.67)	8.18^{b} (65.90)	92.68	90.01	92.14	84.32	65.00
T_2	Pendimethalin 38.7% CS 675 gha^{-1} (PE) *fb* propaquizafop 10% EC 62.5 gha^{-1} at 2-3 leaf stage (PoE) *fb* intercultivation at 45 DAS.	4.04^{b} (15.30)	6.69^{f} (43.73)	5.78^{b} (32.40)	8.53^{b} (71.83)	86.18	85.78	91.12	82.91	25.72
T_3	Oxadiargyl 80% WP 90 gha^{-1} (PE) *fb propaquizafop* 10% EC 62.5 gha^{-1} at 2-3 leaf stage (PoE) *fb* intercultivation at 45 DAS.	4.13^{b} (16.10)	7.16^{g} (50.73)	7.18^{c} (51.13)	9.78^{c} (94.64)	85.46	83.50	85.99	77.49	31.53
T_4	Oxyfluorfen 23.5% EC 0.2 kgha^{-1} (PE) followed by rice straw mulch (5tha^{-1}) at 7-10 DAS.	3.21^{a} (9.30)	5.98^{e} (34.73)	10.07^{d} (100.43)	11.46^{d} (130.40)	91.60	88.71	72.48	68.98	63.29
T_5	Pendimethalin 38.7% CS 675 gha^{-1} *fb* rice straw mulch (5tha^{-1}) at 7-10 DAS.	4.85^{c} (22.50)	9.30^{h} (85.47)	11.48^{ef} (130.87)	12.31^{e} (150.54)	79.67	72.21	64.14	64.19	36.91
T_6	Oxadiargyl 80% WP 90 g ha^{-1}*fb* rice straw mulch (5t ha^{-1}) at 7-10 DAS	5.02^{cd} (24.20)	10.45^{i} (108.20)	11.29^{e} (126.40)	13.46^{g} (180.14)	78.14	64.82	65.37	57.15	35.66
T_7	Rice straw mulch at 7-10 DAS (5tha^{-1}).	5.23^{d} (26.40)	10.64^{j} (112.13)	11.69^{f} (137.77)	12.72^{f} (160.78)	76.15	63.55	62.25	61.75	22.70
T_8	Black polythene mulch.	3.79^{b} (13.40)	3.51^{b} (11.30)	5.06^{a} (24.60)	5.15^{a} (25.58)	87.90	96.33	93.26	93.92	-
T_9	Stale seed bed followed by intercropping with green leafy vegetables (palak).	6.58^{e} (42.76)	11.78^{j} (137.73)	13.41^{g} (178.87)	14.47^{h} (208.35)	61.37	55.22	50.99	50.44	45.94
T_{10}	Mechanical weeding at 15, 30, 60 DAS.	3.05^{a} (8.30)	5.12^{c} (25.70)	9.95^{d} (98.53)	14.73^{h} (215.87)	92.50	91.64	73.00	48.65	39.88
T_{11}	Mechanical weeding (inter row) followed by hand weeding (intra row) at 30 and 60 DAS - (weed free check).	10.28^{f} (105.21)	2.66^{a} (6.10)	4.88^{a} (22.87)	5.52^{a} (29.49)	4.96	98.02	93.73	92.98	1.83
T_{12}	Unweeded Control	10.57^{f} (110.70)	17.57^{k} (307.60)	19.13^{h} (364.97)	20.53^{i} (420.38)	-	-	-	-	73.11
	SE (m)±	0.12	0.08	0.09	0.09					
	CD at 5%	0.36	0.23	0.26	0.27					

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