



# Evaluating Herbicide Combinations and Mechanical Methods for Sustainable Weed Management in Irrigated Groundnut (*Arachis hypogaea* L.)

Bramhanapalli Vishnu <sup>a++\*</sup>, M. Silambarasan <sup>b#</sup>,  
K. Udhaya Kumar <sup>b#</sup> and D. Naresh <sup>ct</sup>

<sup>a</sup> Department of Agriculture, Division of Agronomy, Karunya Institute of Technology and Science, Coimbatore, India.

<sup>b</sup> Division of Agronomy, School of Agriculture and Bio Sciences, Karunya Institute of Technology and Science, Coimbatore, India.

<sup>c</sup> ICAR-KVK, Gaddypalli, Telengana, India.

## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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## ABSTRACT

The present study evaluates herbicide combinations and mechanical methods for sustainable weed management in irrigated groundnut (*Arachis hypogaea* L.). Integrated weed management

<sup>++</sup> Research Scholar;

<sup>#</sup> Research Guide, Assistant Professor;

<sup>†</sup> Agronomy Scientist;

\*Corresponding author: E-mail: [Vishnuaidea2@gmail.com](mailto:Vishnuaidea2@gmail.com);

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strategies, combining cultural, mechanical, and chemical methods, are recommended for sustainable weed control in groundnut fields. Various factors limiting the groundnut production and weeds are the primary factors which significantly reduce the crop yield. Weeds compete with groundnut for essential resources such as nutrients, water and space particularly during the early stages of crop growth, which is highly susceptible to weed competition due to its initial slow growth. A field experiment was conducted at Farmers field, Penumuru mandal, Chittoor district of Andhra Pradesh during Rabi seasons of 2023 – 24. Field experiment was laid out in Randomized Complete Block Design and replicated thrice with the following treatments viz., T1 - PE pendimethalin 1.00 kg ha<sup>-1</sup>, T2 - PE pendimethalin @ 1.00 kg ha<sup>-1</sup> + Hand weeding on 30 DAS, T3 - PE pendimethalin @ 1.00 kg ha<sup>-1</sup> + Twin wheel hoe weeding on 30 DAS, T4 - PE pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE imazethapyr @ 0.050 kg ha<sup>-1</sup> on 15-20 DAS, T5 - PE pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE quizalofop ethyl @ 0.250 kg ha<sup>-1</sup>, T6- oxyfluorfen 0.250 kg ha<sup>-1</sup>, T7 - PE oxyfluorfen @ 0.250 kg ha<sup>-1</sup> + Hand weeding on 30 DAS, T8 - PE oxyfluorfen @ 0.250 kg ha<sup>-1</sup> + Twin wheel hoe weeding on 30 DAS, T9- PE oxyfluorfen @ 0.250 kg ha<sup>-1</sup> + EPOE imazethapyr @ 0.050 kg ha<sup>-1</sup> on 15-20 DAS, T10 – PE oxyfluorfen @ 0.250 kg ha<sup>-1</sup> + EPOE quizalofop ethyl @ 0.075 kg ha<sup>-1</sup>, T11 - Twin wheel hoe weeding on 20 and 45 DAS, T12 - Unweeded check. Growth parameters viz., plant height, number of branches plant<sup>-1</sup>, number of leaves plant<sup>-1</sup>, dry matter production and leaf area were recorded at 30 DAS, 60 DAS, 90 DAS and harvest stage. It was found higher with the pre-emergence application of pendimethalin at 0.75 kg ha<sup>-1</sup> combined with early post-emergence imazethapyr at 0.050 kg ha<sup>-1</sup>. Physiological parameters which include leaf area index (LAI), crop growth rate (CGR), relative growth rate (RGR), and net assimilation rate (NAR) were estimated. The pre-emergence application of pendimethalin at 0.75 kg ha<sup>-1</sup> combined with early post-emergence imazethapyr at 0.050 kg ha<sup>-1</sup> had maximum values of physiological parameters compared with other treatments at 60-90 DAS and 60-harvest stage.

**Keywords:** Groundnut; herbicide; pendimethalin; quizalofop.

## 1. INTRODUCTION

“Weeds undesirably affect yield, quality and economic value as they compete for water, nutrients and light all through the growing season. The groundnut crop production is subject to various agronomic management practices and there are numerous reasons for its low productivity. The low productivity of groundnut is mainly due to the problem of weed infestation” (Sarin et al., 2021; Ravi et al., 2024). The groundnut (*Arachis hypogaea* L.), is a highly valued legume crop with numerous applications in food production, agriculture, and industry. It is also known as peanut, earthnut, or monkey nut. Groundnuts is native to South America, where they have been cultivated for more than 3,500 years (Ravikumar et al., 2020). It's a staple food for millions of people and a significant source of income in many countries, particularly in tropical or subtropical climatic regions. The major producers are the United States, Sudan, China, India and Nigeria (Kumar et al., 2024). Global groundnut production reached approximately 51 million tonnes, cultivated on about 32 m ha<sup>-1</sup>, with an average yield of 1600 kg ha<sup>-1</sup> in 2023. China, India, and Nigeria were the top three producers globally (FAOSTAT, 2023). In 2023, India's groundnut sector experienced notable

shifts. The crop is now cultivated on approximately 45.53 lakh hectares with a total production of 78.29 lakh tonnes during kharif season of 2023-24 and a slight decrease from the previous year's 85.62 lakh tonnes, with an average productivity of 1719 kg ha<sup>-1</sup>. Gujarat maintains its position as the leading producer, contributing 33% of total output, followed by Rajasthan at 21% and Tamil Nadu at 14%. Tamil Nadu continues to demonstrate strong performance in the sector, cultivating groundnuts on 3.40 lakh hectares, yielding about 10.13 lakh tonnes, and achieving an impressive productivity rate of 2980 kg ha<sup>-1</sup> (FAOSTAT, 2023). The states of Gujarat, Rajasthan, and Tamil Nadu were the leading producers in India (Srinivasan et al., 2024). Groundnut is recognized as one of the world's important oilseed crops due to its superior nutritional profile and versatile applications. The quality of groundnuts is determined by several key parameters, including oil content (45-55%), protein content (22-30%), and fatty acid composition (Mishra, 2020). The high oleic acid content in modern cultivars, ranging from 60-80%, contributes to improved oil stability and extended shelf life. Groundnuts are also rich in essential minerals like phosphorus, calcium, magnesium, and potassium, as well as vitamins E, K, and B complex. Moreover, the

absence of cholesterol and low sodium content make groundnut oil is a heart-healthy option for consumption. Various factors limiting groundnut production and weeds are the primary factors which significantly reduce the crop yield. Weeds compete with groundnut for essential resources such as nutrients, water and space, particularly during the early stages of crop growth, which is highly susceptible to weed competition due to its initial slow growth (Chaitanya *et al.*, 2012). Many researchers found that uncontrolled weed infestations can lead to yield reductions of up to 50% or even more, depending on the severity and composition of weed flora (Charitha *et al.*, 2024). Therefore, effective weed management is crucial to minimizing yield losses and ensuring optimal groundnut productivity. Integrated weed management strategies, combining cultural, mechanical, and chemical methods, are recommended for sustainable weed control in groundnut fields (Ramalingam *et al.*, 2013). Early-season weed control is particularly important, as groundnut is most susceptible to weed competition during the first 4-6 weeks after sowing (Samant *et al.*, 2014). Imazethapyr and Quizalofop are both systemic, selective post-emergence herbicides used to control weeds. Imazethapyr is absorbed by both the foliage and the root system, while Quizalofop is primarily absorbed through the foliage and then translocated to the root system (Ramesh, 2016). These herbicides are transported through both xylem and phloem, which accumulate in the meristematic regions within 24 hours. In these meristematic tissues, the herbicides inhibit the synthesis of acetolactate (ALC), which is crucial for protein production (Kumari *et al.*, 2023). This disruption in protein synthesis interferes with DNA replication and cell growth, ultimately leading to the death of the weeds (Kakade *et al.*, 2020). The present study evaluates herbicide combinations and mechanical methods for sustainable weed management in irrigated groundnut (*Arachis hypogaea* L.).

## 2. MATERIALS AND METHODS

The study was conducted in a farmer's field located in Penumuru mandal, Chittoor District, Andhra Pradesh. This experimental site is situated approximately 56 kilometers southeast of Tirupathi, placing it in a sub-tropical climatic zone. Geographically, the field is positioned at 26°47' North latitude and 82°12' East longitude. The elevation of the site is 113 meters above mean sea level, contributing to its unique agricultural characteristics. This location was chosen to represent typical farming conditions in

the region. Tirupathi hills are situated in a transitional climatic zone ranging from semi-arid to sub-humid. The monsoon season typically commences in the first week of December and extends through the first week of March. With an average annual precipitation of 1,073 mm, approximately 80% is attributed to the southwest monsoon. However, the region experiences a significant soil moisture deficit, as the annual potential evapotranspiration reaches 1,667 mm. The temperature profile exhibits an upward trend beginning in February, peaking in March. The meteorological data pertaining to the 2023-24 crop season, including total rainfall, temperature, relative humidity, sunshine duration, and evaporation, were recorded on a weekly basis at the Sri Venkateswara Agriculture College, Tirupati Meteorological Observatory. The experimental period was characterized by suboptimal rainfall conditions. A week prior to sowing, the absence of precipitation necessitated pre-sowing irrigation for groundnut cultivation. During the 2023-24 crop season, the cumulative rainfall was notably low at 1.0 mm. Weekly mean maximum temperatures fluctuated between 14.5°C and 34.3°C, averaging 25.5°C. Relative humidity varied from 54.6% to 87.9%, with a mean of 70.3% throughout the season. Similarly, mean wind speeds ranged from 1.0 to 4.2 km/h, averaging 2.6 km/h. The groundnut (TMV 7) was raised at the experimental location during the *rabi* season of 2023-24 (January to May). The physical features of the groundnut TMV 7 variety was presented in Table 1.

To identify effective weed management strategies for irrigated groundnut, with an emphasis on minimizing herbicide residue. The study evaluated the efficacy of newer herbicide molecules in various combinations, comparing them against conventional methods. These conventional methods included recommended pre- and post-emergence herbicides, manual weeding twice, and a weed-free check. The primary objective was to enhance groundnut production while maintaining environmental sustainability through judicious herbicide use. The experiments were set up using a Randomized Complete Block Design (RBD) with three replications.

### 3.1 Observation Recording

Observation on weed parameters Weed observations were recorded at 30, 60 and 4 days after sowing (DAS), as well as at the harvest stage.

**Table 1. Physical features of groundnut TMV 7 Variety**

Year of release	1967
Origin	Selection from Tennessee
Duration	105 days
Habit group	Bunch
100 seed weight. G	44
Special features	Dormancy for 10 days
Average yield (kg ha <sup>-1</sup> )	1400
Oil content (%)	49.6

**Table 2. Details of field experiment**

Particulars	Details of experiment
Season	Rabi (November - March, 2023-24)
Design of experiment	Randomized Complete Block Design
Number of treatments	12
Number of replications	3
Crop	Groundnut
Variety	TMV 7
Spacing	30 cm x 10 cm
Gross plot size	5 m x 4.5 m
Net plot size	4.6 m x 3.3 m

**Table 3. The details of the treatments were given below**

T <sub>1</sub> -	PE pendimethalin 1.00 kg ha <sup>-1</sup>
T <sub>2</sub> -	PE pendimethalin 0.75 kg ha <sup>-1</sup> + EPOE imazethapyr 0.050 kg/ha on 15-20 DAS
T <sub>3</sub> -	PE pendimethalin 1.00 kg ha <sup>-1</sup> + Twin wheel hoe weeding on 30 DAS
T <sub>4</sub> -	PE pendimethalin 0.75 kg ha <sup>-1</sup> + EPOE imazethapyr 0.050 kg/ha on 15-20 DAS
T <sub>5</sub> -	PE pendimethalin 0.75 kg ha <sup>-1</sup> + EPOE quizalofop ethyl 0.075 kg/ha on 15-20 DAS
T <sub>6</sub> -	PE oxyfluorfen 0.250 kg ha <sup>-1</sup>
T <sub>7</sub> -	PE oxyfluorfen 0.250 kg ha <sup>-1</sup> + Hand weeding on 30 DAS
T <sub>8</sub> -	PE oxyfluorfen 0.250 kg ha <sup>-1</sup> + Twin wheel hoe weeding on 30 DAS
T <sub>9</sub> -	PE oxyfluorfen 0.250 kg ha <sup>-1</sup> + EPOE imazethapyr 0.050 kg ha <sup>-1</sup> on 15-20 DAS
T <sub>10</sub> -	PE oxyfluorfen 0.250 kg ha <sup>-1</sup> + EPOE quizalofopethyl 0.075 kg ha <sup>-1</sup>
T <sub>11</sub> -	Twin wheel hoe weeding on 20 and 45 DAS
T <sub>12</sub> -	Control

1. Effect of different weed management practices on plant height (cm)
2. Effect of different weed management practices on number of leaves plant -1
3. Effect of weed management practices on number of branches per plant
4. Effect of weed management practices on dry matter production (kg ha<sup>-1</sup>)
5. Effect of weed management practices on leaf area (cm<sup>2</sup>)

### 3.3 Nutrient Uptake by Groundnut and Weeds

1. Effect of weed management practices on nutrient uptake by crop at 60 DAS
2. Effect of weed management practices on nutrient uptake by crop at harvest:
3. Effect of weed management practices on nutrient uptake by weed at 60 DAS:
4. Effect of weed management practices on nutrient uptake by weed at harvest:

### 3.2 Physiological Parameters of Groundnut

1. Effect of weed management practices on leaf area index (LAI)
2. Effect of weed management practices on relative growth rate (g g<sup>-1</sup> day<sup>-1</sup>):

## 4. RESULTS AND DISCUSSION

A field experiment was conducted at Farmers Field, Penumurumandal, Chittoor district of Andhra Pradesh during Rabi seasons of 2023 – 24 to assess the newer herbicide combinations and identify practical weed management

techniques for groundnut. The results of collected data from the experimental field with statistical analysis are described and presented in this chapter.

## 4.1 Growth Parameters of Groundnut

Growth parameters of groundnut were highly influenced by different nutrient management practices and results are discussed below. It includes plant height (cm), number of leaves plant-1, leaf area (cm<sup>2</sup>), number of branches per plant and dry matter production (g plant-1).

### 4.1.1 Effect of different weed management practices on plant height (cm)

Table 4 shows that plant height was significantly influenced by different weed management treatments at all the stages of crop growth. At 30 DAS, higher plant height were recorded in pre emergence application of pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE imazethapyr @ 0.050 kg ha<sup>-1</sup> applied at 15-20 DAS (T4) and it was on par with (T5) PE pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE quizalofop ethyl @ 0.075 kg ha<sup>-1</sup> on 15-20 DAS (8.31), PE pendimethalin @ 1.00 kg ha<sup>-1</sup> + Hand weeding on 30 DAS (8.24) and PE oxyfluorfen @ 0.250 kg ha<sup>-1</sup> + EPOE imazethapyr @ 0.050 kg ha<sup>-1</sup> on 15-20 DAS (8.21). The unweeded control (T12) had the lowest plant height of 7.21 cm at 30 DAS indicating that early weed competition hindered initial growth. At 60 DAS, (T4) pre emergence application of pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE imazethapyr @ 0.050 kg ha<sup>-1</sup> applied at 15-20 DAS showed the maximum plant height (31.19 cm) and it is on par with (T6) PE pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE quizalofop ethyl @ 0.075 kg ha<sup>-1</sup> on 15-20 DAS (30.62 cm) followed by (T2) PE pendimethalin @ 1.00 kg ha<sup>-1</sup> + Hand weeding on 30 DAS. In contrast, unweeded check (T12) recorded the shortest height (18.07 cm), highlighting the detrimental impact of weeds. The similar trend was continued at 90 DAS and harvest stage of groundnut. The pre emergence application of pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE imazethapyr @ 0.050 kg ha<sup>-1</sup> applied at 15-20 DAS continued to have the tallest plants (40.60 cm at 90 DAS and 42.10 cm at harvest stage) followed by (T5) PE pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE quizalofop ethyl @ 0.075 kg ha<sup>-1</sup> 57 on 15-20 DAS (39.26 at 90 DAS and 41.04 at harvest). Unweeded check remained the shortest

(21.05 cm at 90 DAS and 24.98 at harvest), confirming the negative effect of weed presence. similarly, results found in (Charitha et al., 2024)

### 4.1.2 Effect of different weed management practices on number of leaves plant -1

Based on the data presented in Table 4, the number of leaves per plant was significantly influenced by different weed management treatments at all growth stages (30 DAS, 60 DAS, 90 DAS, and at harvest). At 30 DAS, a higher number of leaves were recorded in (T4) pre emergence application of pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE imazethapyr @ 0.050 kg ha<sup>-1</sup> applied at 15-20 DAS (13.67) and it was on par with (T5) PE pendimethalin @ 0.75 kg ha<sup>-1</sup> on 15-20 DAS (13.33), PE pendimethalin @ 1.00 kg ha<sup>-1</sup> + Hand weeding on 30 DAS (13.00), PE oxyfluorfen @ 0.250 kg ha<sup>-1</sup> + EPOE imazethapyr @ 0.050 kg ha<sup>-1</sup> on 15-20 DAS (12.67) and PE oxyfluorfen @ 0.250 kg ha<sup>-1</sup> + EPOE quizalofop ethyl @ 0.075 kg ha<sup>-1</sup> (12.67). The unweeded control (T12) had the lowest number of leaves (12.67) at 30 DAS indicating that early weed competition hindered initial growth. In a similar way, the pre emergence application of pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE imazethapyr @ 0.050 kg ha<sup>-1</sup> applied at 15-20 DAS observed the highest number of leaf counts at 60 DAS (34.33), 90 DAS (42.33) and at harvest stage (16.00). At 90 DAS, the on par values with T4 observed in the treatments of PE pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE quizalofop ethyl @ 0.075 kg ha<sup>-1</sup> on 15-20 DAS (41.0), PE pendimethalin @ 1.00 kg ha<sup>-1</sup> + Hand weeding on 30 DAS (41), PE oxyfluorfen @ 0.250 kg ha<sup>-1</sup> + EPOE imazethapyr @ 0.050 kg ha<sup>-1</sup> on 15-20 DAS (40.67) and PE oxyfluorfen @ 0.250 kg ha<sup>-1</sup> + EPOE quizalofop ethyl @ 0.075 kg ha<sup>-1</sup> (40.33). The lower leaf count was measured with unweeded check (22.0) at 90 DAS. In harvest stage, on par values with T4 were noticed in the treatments of (T5) PE pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE quizalofop ethyl @ 0.075 kg ha<sup>-1</sup> on 15-20 DAS (15.33) and (T2) PE pendimethalin @ 1.00 kg ha<sup>-1</sup> + Hand weeding on 30 DAS (15.0) Reduced weed pressure results in improved light interception and nutrient availability, which are crucial for leaf development and overall plant health (Kumari et al., 2020;). Studies have shown that effective weed management enhances leaf production by mitigating competition for essential growth resources.

**Table 4. Effect of different weed management practices in different treatment efficacy**

Treatments	Effect of different weed management practices on plant height (cm)				Effect of different weed management practices on number of leaves plant <sup>-1</sup>				Effect of weed management practices on number of branches plant <sup>-1</sup>				Effect of weed management practices on dry matter production (kg ha <sup>-1</sup> )				Effect of weed management practices on leaf area (cm <sup>2</sup> )			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T <sub>1</sub> - PE pendimethalin 1.00 kg ha <sup>-1</sup> .	7.4	22.93	29.56	30.95	11	23.67	29.67	9.33	1.67	3.33	3.67	3.33	1.81	10.79	14.12	12.83	3.6	11.1	17.02	14.85
T <sub>2</sub> - PE pendimethalin 1.00 kg ha <sup>-1</sup> + Hand weeding on 30 DAS.	8.24	30.27	37.55	39.1	13	32	41	15	2.33	5.33	5.67	5	2.21	13.85	21.16	20.13	6	16.2	21.84	18.5
T <sub>3</sub> - PE pendimethalin 1.00 kg ha <sup>-1</sup> + Twin wheel hoe weeding on 30 DAS.	7.97	27.66	35.09	35.58	12.33	31	39.67	13.33	2	4.33	4.67	4.33	2.07	12.76	20.2	15.41	4.76	13.86	19.11	16.92
T <sub>4</sub> - PE pendimethalin 0.75 kg ha <sup>-1</sup> + EPOE imazethapyr 0.050 kg ha <sup>-1</sup> on 15-20 DAS.	8.43	31.19	40.6	42.1	13.67	34.33	42.33	16	3	5.67	6	5.67	2.54	14.8	23.26	20.99	7.14	17.76	23.52	19.76
T <sub>5</sub> - PE pendimethalin 0.75 kg ha <sup>-1</sup> + EPOE quizalofop ethyl 0.075 kg ha <sup>-1</sup> on 15-20 DAS	8.31	30.62	39.26	41.04	13.33	32.67	41	15.33	2.33	5.33	5.67	5.33	2.34	14.62	22.49	20.11	6.6	16.56	22	19.38
T <sub>6</sub> - PE oxyfluorfen 0.250 kg ha <sup>-1</sup>	7.32	21.31	26.1	28.04	10.33	19.67	26	8.67	1.67	2.67	3	3	1.76	10.12	11.9	11.88	3.22	9.8	15.75	13.02
T <sub>7</sub> - PE oxyfluorfen 0.250 kg ha <sup>-1</sup> + Hand weeding on 30 DAS.	7.57	25.32	33.21	34.7	11.67	27.33	35.67	11.67	1.67	4	4	4	1.89	11.59	16.93	13.32	4.16	12.4	17.76	16.1
T <sub>8</sub> - PE oxyfluorfen 0.250 kg ha <sup>-1</sup> + Twin wheel hoe weeding on 30 DAS.	7.71	26.81	33.95	34.27	12.33	29	38.33	13	2	4	4.67	4.33	1.98	12.34	18.05	13.96	4.59	13.12	18.62	16.45
T <sub>9</sub> - PE oxyfluorfen 0.250 kg ha <sup>-1</sup> + EPOE imazethapyr 0.050 kg ha <sup>-1</sup> on 15-20 DAS	8.21	30.05	36.39	37.38	12.67	31.33	40.67	14.33	2.33	4.67	5.33	4.67	2.19	13.54	21.7	17.86	5.51	15.05	20.91	18.13
T <sub>10</sub> - PE oxyfluorfen 0.250 kg ha <sup>-1</sup> + EPOE quizalofop ethyl 0.075 kg ha <sup>-1</sup> .	7.92	28.68	36.05	36.58	12.67	31	40.33	13.67	2.33	4.33	5	4.67	2.18	13	20.23	16.62	5.04	14.28	20	17.28
T <sub>11</sub> - Twin wheel hoe weeding on 20 and 45 DAS.	7.49	24.91	31.64	32.55	11	24.33	33.67	11.33	1.67	3.33	4	3.33	1.85	11.39	16.18	13.22	3.9	11.4	17.48	15.3
T <sub>12</sub> - Unweeded check.	7.21	18.07	21.05	24.98	9.67	16.33	22	7	1.33	2.67	3	2.67	1.75	7.71	11.26	9.98	2.52	8	12	10.26
S. Ed	0.14	0.5	0.36	0.59	0.48	0.78	1.06	0.57	0.4	0.47	0.42	0.39	0.02	0.22	0.23	0.19	0.12	0.34	0.35	0.39
CD at 5 %	0.3	1.03	0.75	1.22	1	1.61	2.2	1.18	0.83	0.97	0.88	0.8	0.05	0.45	0.47	0.4	0.25	0.7	0.72	0.82

**Table 5. Effect of weed management practices on nutrient uptake by weed at harvest**

Treatments	Effect of weed management practices on leaf area index (LAI)		Effect of weed management practices on crop growth rate		Effect of weed management practices on relative growth rate (RGR)		Effect of weed management practices on net assimilation rate (NAR)		Effect of weed management practices on nutrient uptake by crop at 60 DAS			Effect of weed management practices on nutrient uptake by crop at harvest			Effect of weed management practices on nutrient uptake by weed at 60 DAS			Effect of weed management practices on nutrient uptake by weed at harvest		
	90 DAS	At harvest	CGR (g cm <sup>-2</sup> day <sup>-1</sup> )		RGR (g g <sup>-1</sup> day <sup>-1</sup> )		NAR (g cm <sup>-2</sup> day <sup>-1</sup> )		Crop uptake (kg ha <sup>-1</sup> )			Crop uptake (kg ha <sup>-1</sup> )			Weed uptake (kg ha <sup>-1</sup> )			Weed uptake (kg ha <sup>-1</sup> )		
			60-90 DAS	90-At harvest	60-90 DAS	90-At harvest	60-90 DAS	90-At harvest	N	P	K	N	P	K	N	P	K	N	P	K
T <sub>1</sub> - PE pendimethalin 1.00 kg ha <sup>-1</sup> .	3.6	11.1	3.45	2.36	0.0142	0.002	0.0693	0.0137	59.98	7.51	44.14	117.8	7.98	56.04	5.16	0.42	3.25	5.88	0.85	4.22
T <sub>2</sub> - PE pendimethalin 1.00 kg ha <sup>-1</sup> + Hand weeding on 30 DAS.	6	16.2	4.69	3.92	0.0157	0.0032	0.074	0.021	86.22	10.7	59.45	173.78	15.11	80.88	2.09	0.21	1.92	2.69	0.4	2.48
T <sub>3</sub> - PE pendimethalin 1.00 kg ha <sup>-1</sup> + Twin wheel hoe weeding on 30 DAS.	4.76	13.86	4.19	2.66	0.0153	0.0025	0.0725	0.0178	74.46	9.67	54.47	147.92	12.02	67.91	3.74	0.31	2.58	4.19	0.6	3.09
T <sub>4</sub> - PE pendimethalin 0.75 kg ha <sup>-1</sup> + EPOE imazethapyr 0.050 kg ha <sup>-1</sup> on 15-20 DAS.	7.14	17.76	5.02	4.1	0.0165	0.0037	0.0747	0.0247	95.47	11.86	62.56	207.17	16.98	90.06	1.62	0.1	1.39	2.12	0.21	2.01
T <sub>5</sub> - PE pendimethalin 0.75 kg ha <sup>-1</sup> + EPOE quizalofop ethyl 0.075 kg ha <sup>-1</sup> on 15-20 DAS	6.6	16.56	4.86	4.07	0.0161	0.0035	0.0741	0.0211	88.42	11.23	61.75	182.23	16	84.08	1.85	0.18	1.66	2.4	0.35	2.27
T <sub>6</sub> - PE oxyfluorfen 0.250 kg ha <sup>-1</sup>	3.22	9.8	3.19	2.3	0.0134	0.0018	0.0685	0.0135	55.83	6.48	41.17	110.22	6.92	54.08	5.51	0.46	3.38	6.32	0.9	4.72
T <sub>7</sub> - PE oxyfluorfen 0.250 kg ha <sup>-1</sup> + Hand weeding on 30 DAS.	4.16	12.4	3.95	2.52	0.0148	0.0022	0.0705	0.0142	72.52	8.58	52	124.17	10.01	61.17	4.39	0.37	2.98	5.07	0.74	3.75
T <sub>8</sub> - PE	4.59	13.12	4.04	2.59	0.0151	0.0024	0.0706	0.0144	73.25	9.28	54.21	134.78	10.87	64.77	4.14	0.33	2.84	4.63	0.66	3.5

Treatments	Effect of weed management practices on leaf area index (LAI)		Effect of weed management practices on crop growth rate		Effect of weed management practices on relative growth rate (RGR)		Effect of weed management practices on net assimilation rate (NAR)		Effect of weed management practices on nutrient uptake by crop at 60 DAS			Effect of weed management practices on nutrient uptake by crop at harvest			Effect of weed management practices on nutrient uptake by weed at 60 DAS			Effect of weed management practices on nutrient uptake by weed at harvest			
	90 DAS	At harvest	CGR (g cm <sup>-2</sup> day <sup>-1</sup> )		RGR (g g <sup>-1</sup> day <sup>-1</sup> )		NAR (g cm <sup>-2</sup> day <sup>-1</sup> )		Crop uptake (kg ha <sup>-1</sup> )			Crop uptake (kg ha <sup>-1</sup> )			Weed uptake (kg ha <sup>-1</sup> )			Weed uptake (kg ha <sup>-1</sup> )			
			60-90 DAS	90-At harvest	60-90 DAS	90-At harvest	60-90 DAS	90-At harvest	N	P	K	N	P	K	N	P	K	N	P	K	
oxyfluorfen 0.250 kg ha <sup>-1</sup> + Twin wheel hoe weeding on 30 DAS.																					
T <sub>9</sub> - PE oxyfluorfen 0.250 kg ha <sup>-1</sup> + EPOE imazethapyr 0.050 kg ha <sup>-1</sup> on 15-20 DAS	5.51	15.05	4.54	3.81	0.0156	0.003	0.073	0.0209	80.55	10.29	57.23	166.83	14	75.87	2.68	0.25	2.09	3.47	0.47	2.66	
T <sub>10</sub> - PE oxyfluorfen 0.250 kg ha <sup>-1</sup> + EPOE quizalofop ethyl 0.075 kg ha <sup>-1</sup> .	5.04	14.28	4.45	3.63	0.0155	0.0028	0.0729	0.0201	76.63	10.03	54.78	154.83	12.87	70.66	3.45	0.28	2.35	3.77	0.57	2.88	
T <sub>11</sub> - Twin wheel hoe weeding on 20 and 45 DAS.	3.9	11.4	3.74	2.4	0.0146	0.0021	0.07	0.0138	64.11	8.37	48.48	118.6	9.04	59.24	4.81	0.4	3.1	5.39	0.8	3.95	
T <sub>12</sub> - Unweeded check.	2.52	8	3	2.12	0.013	0.0015	0.0668	0.0124	50.87	4.22	37.34	101.25	6	50.69	5.73	0.51	3.61	6.7	0.97	5.47	
S. Ed	0.12	0.34	0.09	0.06	0.0002	0.000044	0.00101	0.0002	0.78	0.17	0.71	1.8	0.14	1.09	0.07	0.01	0.05	0.09	0.01	0.06	
CD at 5 %	0.25	0.7	0.19	0.13	0.00042	0.000092	0.00209	0.00041	1.63	0.35	1.47	3.73	0.29	2.27	0.15	0.01	0.1	0.19	0.03	0.13	

#### 4.1.3 Effect of weed management practices on number of branches per plant

There is a significant difference in various treatments on number of branches were noticed at 30 DAS, 60 DAS, 90 DAS and the harvest stage of groundnut and data on number of branches mentioned in Table 4. At 30 DAS, a maximum number of branches were noticed with pre emergence application of pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE imazethapyr @ 0.050 kg ha<sup>-1</sup> on 15-20 DAS (3.00) followed by (T5) PE pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE quizalofop ethyl @ 0.075 kg ha<sup>-1</sup> on 15-20 DAS (2.33), (T2) PE pendimethalin @ 1.00 kg ha<sup>-1</sup> + Hand weeding on 30 DAS (2.33), (T9) PE oxyfluorfen @ 0.250 kg ha<sup>-1</sup> + EPOE imazethapyr @ 0.050 kg ha<sup>-1</sup> on 15-20 DAS (2.33) and (T10) PE oxyfluorfen @ 0.250 kg ha<sup>-1</sup> + EPOE quizalofop ethyl @ 0.075 kg ha<sup>-1</sup> (2.33). In similar way the later stages of plant growth, the pre emergence application of pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE @ imazethapyr 0.050 kg ha<sup>-1</sup> applied at 15-20 DAS recorded the highest number of branches at 60 DAS (5.67) which is on par with (T5) PE pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE quizalofop ethyl @ 0.075 kg ha<sup>-1</sup> on 15-20 DAS (5.33) followed by (T2) PE pendimethalin @ 1.00 kg ha<sup>-1</sup> + Hand weeding on 30 DAS (5.33). Similar trend was observed at 90 DAS (6.00) and at harvest stage (5.67). In 90 DAS, the higher values are on par with (T5) PE pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE quizalofop ethyl @ 0.075 kg ha<sup>-1</sup> on 15-20 DAS (5.67), (T2) PE pendimethalin @ 1.00 kg ha<sup>-1</sup> + Hand weeding on 30 DAS (5.67) and (T9) PE oxyfluorfen @ 0.250 kg ha<sup>-1</sup> + EPOE imazethapyr @ 0.050 kg ha<sup>-1</sup> on 15-20 DAS (5.33). Whereas at harvest stage of groundnut, the higher value was on par with (T5) PE pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE quizalofop ethyl @ 0.075 kg ha<sup>-1</sup> on 15 20 DAS (5.33) and (T2) PE pendimethalin @ 1.00 kg ha<sup>-1</sup> + Hand weeding on 30 DAS (5.00). The lower values on branches were observed with unweeded checks at 30 DAS (1.33), 60 DAS (2.67), 90 DAS (3.00) and harvest stage (2.67). This improved resource availability leads to enhanced plant growth and development, resulting in a higher number of branches (Adhikary et al., 2016).

#### 4.1.4 Effect of weed management practices on dry matter production (kg ha<sup>-1</sup>)

There is a significant difference in treatments with dry matter production noticed at 30 DAS, 60

DAS, 90 DAS and the harvest stage of groundnut and the data was mentioned in Table 4. At 30 DAS, higher values on dry matter production were noticed in (T4) pre-emergence application of pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE imazethapyr @ 0.050 kg ha<sup>-1</sup> on 15-20 DAS (2.54) followed by (T5) PE pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE quizalofop ethyl @ 0.075 kg ha<sup>-1</sup> on 15-20 DAS (2.34) and (T2) PE pendimethalin @ 1.00 kg ha<sup>-1</sup> + Hand weeding on 30 DAS (2.21). Similar to this, pre emergence application of pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE imazethapyr @ 0.050 kg ha<sup>-1</sup> on 15-20 DAS observed higher values on dry matter production (kg ha<sup>-1</sup>) at 60 DAS (14.80), 90 DAS (23.26) and harvest stage (20.99) of the groundnut. At 60 DAS, the higher values on dry matter production are on par with (T5) pre emergence application of pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE quizalofop ethyl @ 0.075 kg ha<sup>-1</sup> on 15-20 DAS (14.62). Whereas at 90 DAS and at harvest stage higher values on dry matter production was followed by (T5) PE pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE quizalofop ethyl @ 0.075 kg ha<sup>-1</sup> on 15-20 DAS (22.49 at 90 DAS and 20.11 at harvest stage) and (T2) PE pendimethalin @ 1.00 kg ha<sup>-1</sup> + Hand weeding on 30 DAS (21.16 at 90 DAS and 20.13 at harvest stage). The lower values on dry matter production was observed in (T12) unweeded check at 30 DAS (1.75), 60 DAS (7.71), 90 DAS (11.26) and at harvest stage (9.98) followed by (T6) pre emergence application of oxyfluorfen @ 0.250 kg ha<sup>-1</sup> (1.76 at 30 DAS, 10.12 at 60 DAS, 11.90 at 90 DAS and 11.88 at harvest stage). Rao et al. (2011) stated that weed management strategy results in increased biomass because it minimizes weed-induced stress on the crop, leading to better growth and development.

#### 4.1.5 Effect of weed management practices on leaf area (cm<sup>2</sup>)

Table 4 shows that leaf area per plant it was significantly influenced by different weed management treatments at all growth stages (30 DAS, 60 DAS, 90 DAS, and at harvest). At 30 DAS, maximum leaf area was recorded in (T4) pre emergence application of pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE imazethapyr @ 0.050 kg ha<sup>-1</sup> applied at 15-20 DAS (7.14 cm) followed by (T5) PE pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE quizalofop ethyl @ 0.075 kg ha<sup>-1</sup> on 15-20 DAS (6.60 cm) and PE pendimethalin @ 1.00 kg ha<sup>-1</sup> + Hand weeding on 30 DAS (6.00). The unweeded control (T12) had the lowest leaf area

of 2.52 cm followed by pre emergence application of oxyfluorfen @ 0.250 kg ha<sup>-1</sup> (3.22) In similar way the late stages of plant growth, the pre emergence application of pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE @ imazethapyr 0.050 kg ha<sup>-1</sup> applied at 15-20 DAS observed the highest leaf area at 60 DAS (17.76 cm), 90 DAS (23.52 cm) and at harvest stage (19.76) followed by (T5) PE pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE quizalofop ethyl @ 0.075 kg ha<sup>-1</sup> on 15-20 DAS (16.56 cm at 60 DAS, 22 cm at 90 DAS and 19.38 cm at harvest stage) and PE pendimethalin @ 1.00 kg ha<sup>-1</sup> + Hand weeding on 30 DAS (16.20 cm at 60 DAS, 21.84 cm at 90 DAS and 18.50 cm at harvest stage). The lower values on leaf area at 60 DAS (8.00 cm), 90 DAS (12.0 cm) and at harvest stage (10.26 cm) were observed in unweeded check followed by (T6) PE oxyfluorfen @ 0.250 kg ha<sup>-1</sup> (9.80 at 60 DAS, 15.75 at 90 DAS and 13.02 at harvest stage). Similar findings by Yernaidu et al. (2023) support that effective weed control enhances mustard growth by allowing more efficient resource utilization, ultimately improving yield potential.

## 4.2 Physiological Parameters of Groundnut

### 4.2.1 Effect of weed management practices on leaf area index (LAI)

The data in Table 5 show that different weed management treatments significantly influenced the leaf area index (LAI) of the crop at 90 days after sowing (DAS) and at harvest. At 90 DAS and harvest stage, the higher values on leaf area index were observed with (T4) pre emergence application of pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE imazethapyr @ 0.050 kg ha<sup>-1</sup> on 15-20 DAS (7.14 at 90 DAS and 17.76 at harvest stage) followed by (T5) PE pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE quizalofop ethyl @ 0.075 kg ha<sup>-1</sup> on 15-20 DAS (6.60 at 90 DAS and 16.56 at harvest stage) and (T2) PE pendimethalin @ 1.00 kg ha<sup>-1</sup> + Hand weeding on 30 DAS (6.00 at 90 DAS and 16.20 at harvest stage). Similarly, lower values are associated with (T12) unweeded check at 90 DAS (2.52) and harvest stage (8.00) followed by (T6) pre emergence application of oxyfluorfen @ 0.250 kg ha<sup>-1</sup> (3.22 at 90 DAS and 9.80 at harvest stage). Similarly, Suseendran et al. (2019) found that the strategic use of herbicides not only suppresses weed growth but also improves crop leaf area and biomass, contributing to better overall growth and higher yields.

### 4.2.2 Effect of weed management practices on crop growth rate (g cm<sup>-2</sup> day<sup>-1</sup>)

The data Table 5 reveal the impact of various weed management treatments on crop growth rate (CGR) from 60-90 days after sowing (DAS) and from 90 DAS to harvest. Pre emergence application of pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE imazethapyr @ 0.050 kg ha<sup>-1</sup> at 15-20 DAS achieved the highest CGR, with 5.02 g cm<sup>-2</sup> day<sup>-1</sup> between 60-90 DAS and 4.10 g cm<sup>-2</sup> day<sup>-1</sup> from 90 DAS to harvest. This indicates effective weed control, allowing for better crop growth and biomass accumulation. Pre emergence application of pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE quizalofop ethyl @ 0.075 kg ha<sup>-1</sup> (T5) showed similarly high CGR values, with 4.86 g cm<sup>-2</sup> day<sup>-1</sup> between 60 90 DAS and 4.07 g cm<sup>-2</sup> day<sup>-1</sup> from 90 DAS to harvest and it was on par with pre emergence application of pendimethalin @ 0.75 kg ha<sup>-1</sup> + EPOE imazethapyr @ 0.050 kg ha<sup>-1</sup> at 15-20 DAS. The unweeded check (T12) had the lowest CGR, with 3.00 g cm<sup>-2</sup> day<sup>-1</sup> between 60-90 DAS and 2.12 g cm<sup>-2</sup> day<sup>-1</sup> from 90 DAS to harvest, reflecting the negative impact of weed competition on crop growth. Similarly, Suseendran et al. (2019) found that the strategic use of herbicides not only suppresses weed growth but also improves crop leaf area and biomass, contributing to better overall growth and higher yields.

### 4.2.3 Effect of weed management practices on relative growth rate (g g<sup>-1</sup> day<sup>-1</sup>)

The data reveal the impact of various weed management treatments on the relative growth rate (RGR) of the crop from 60-90 days after sowing (DAS) and from 90 DAS to harvest Table 5 The pre-emergence application of pendimethalin at 0.75 kg ha<sup>-1</sup> combined with an early post-emergence (EPOE) application of imazethapyr at 0.050 kg ha<sup>-1</sup> (T4) at 15-20 DAS achieved the highest RGR, recording 0.0165 g g<sup>-1</sup> day<sup>-1</sup> between 60-90 DAS and 0.0037 g g<sup>-1</sup> day<sup>-1</sup> from 90 DAS to harvest. Similarly, the pre-emergence application of pendimethalin at 0.75 kg ha<sup>-1</sup> followed by an EPOE application of quizalofop ethyl at 0.075 kg ha<sup>-1</sup> (T5) showed high RGR values of 0.0161 g g<sup>-1</sup> day<sup>-1</sup> between 60-90 DAS and 0.0035 g g<sup>-1</sup> day<sup>-1</sup> from 90 DAS to harvest. These values were on par with T4 at 60-90 DAS and demonstrating similar effectiveness in promoting crop growth by reducing weed competition. In contrast, the unweeded check (T12) exhibited the lowest RGR values, with 0.0130 g g<sup>-1</sup> day<sup>-1</sup> between 60-90

DAS and  $0.0015 \text{ g g}^{-1} \text{ day}^{-1}$  from 90 DAS to harvest followed by pre-emergence application of oxyfluorfen at  $0.250 \text{ kg ha}^{-1}$  ( $0.0134 \text{ g g}^{-1} \text{ day}^{-1}$  between 60-90 DAS and  $0.0018 \text{ g g}^{-1} \text{ day}^{-1}$  from 90 DAS to harvest) These results align with findings by Olayinka and Etejere (2015), reported that integrated weed management using herbicides enhances RGR by reducing weed density, thereby allowing crops to access more light, nutrients, and water.

#### 4.2.4 Effect of weed management practices on net assimilation rate ( $\text{g cm}^{-2} \text{ day}^{-1}$ )

The data Table 5 highlight the effect of various weed management treatments on the net assimilation rate (NAR) of the crop during two key growth periods from 60-90 days after sowing (DAS) and 90 DAS to harvest. The pre-emergence application of pendimethalin at  $0.75 \text{ kg ha}^{-1}$  combined with an early post-emergence (EPOE) application of imazethapyr at  $0.050 \text{ kg ha}^{-1}$  (T4) at 15-20 DAS resulted in the highest NAR, with values of  $0.0747 \text{ g cm}^{-2} \text{ day}^{-1}$  between 60-90 DAS and  $0.0247 \text{ g cm}^{-2} \text{ day}^{-1}$  from 90 DAS to harvest. At 60-90 DAS, the higher values on net assimilation rate were on par with (T5) PE pendimethalin  $0.75 \text{ kg ha}^{-1}$  + EPOE quizalofop ethyl  $0.075 \text{ kg ha}^{-1}$  on 15-20 DAS ( $0.0741$ ), (T2) PE pendimethalin  $1.00 \text{ kg ha}^{-1}$  + Hand weeding on 30 DAS ( $0.0740$ ), (T9) PE oxyfluorfen  $0.250 \text{ kg ha}^{-1}$  + EPOE imazethapyr  $0.050 \text{ kg ha}^{-1}$  on 15-20 DAS ( $0.730$ ) and (T10) PE oxyfluorfen  $0.250 \text{ kg ha}^{-1}$  + EPOE quizalofop ethyl  $0.075 \text{ kg ha}^{-1}$  ( $0.0729$ ). At harvest stage the higher values are followed by (T5) PE pendimethalin  $0.75 \text{ kg ha}^{-1}$  + EPOE quizalofop ethyl  $0.075 \text{ kg ha}^{-1}$  on 15 20 DAS ( $0.0211$ ) and (T2) PE pendimethalin  $1.00 \text{ kg ha}^{-1}$  + Hand weeding on 30 DAS ( $0.0210$ ). Conversely, the unweeded check (T12) recorded the lowest NAR values of  $0.0668 \text{ g cm}^{-2} \text{ day}^{-1}$  between 60-90 DAS and  $0.0124 \text{ g cm}^{-2} \text{ day}^{-1}$  from 90 DAS to harvest followed by the pre-emergence application of oxyfluorfen at  $0.250 \text{ kg ha}^{-1}$  (T6) also showed relatively low 62 NAR values of  $0.0685 \text{ g cm}^{-2} \text{ day}^{-1}$  between 60-90 DAS and  $0.0135 \text{ g cm}^{-2} \text{ day}^{-1}$  from 90 DAS to harvest. Similarly, studies by Singh et al. (2017)

### 4.3 Nutrient Uptake by Groundnut and Weeds

#### 4.3.1 Effect of weed management practices on nutrient uptake by crop at 60 DAS

The data illustrate in Table 5 the impact of various weed management treatments on the

nutrient uptake (N, P, K) by the crop at 60 days after sowing (DAS). The pre-emergence application of pendimethalin at  $0.75 \text{ kg ha}^{-1}$  combined with an early post-emergence (EPOE) application of imazethapyr @  $0.050 \text{ kg ha}^{-1}$  at 15-20 DAS resulted in the highest nutrient uptake, with values of  $95.47 \text{ kg ha}^{-1}$  for nitrogen (N),  $11.86 \text{ kg ha}^{-1}$  for phosphorus (P), and  $62.56 \text{ kg ha}^{-1}$  for potassium (K) followed by (T5) PE pendimethalin @  $0.75 \text{ kg ha}^{-1}$  + EPOE quizalofop ethyl @  $0.075 \text{ kg ha}^{-1}$  on 15-20 DAS ( $88.42 \text{ kg ha}^{-1}$  for N,  $11.23 \text{ kg ha}^{-1}$  for P and  $61.75 \text{ kg ha}^{-1}$  for K) and (T2) PE pendimethalin  $1.00 \text{ kg ha}^{-1}$  + Hand weeding on 30 DAS ( $86.22 \text{ kg ha}^{-1}$  for N,  $10.70 \text{ kg ha}^{-1}$  for P and  $59.45 \text{ kg ha}^{-1}$  for K). The unweeded check (T12) showed the lowest nutrient uptake, with values of  $50.87 \text{ kg ha}^{-1}$  for N,  $4.22 \text{ kg ha}^{-1}$  for P, and  $37.34 \text{ kg ha}^{-1}$  for K followed by (T6) the pre-emergence application of oxyfluorfen at  $0.250 \text{ kg ha}^{-1}$  ( $55.83 \text{ kg ha}^{-1}$  for N,  $6.48 \text{ kg ha}^{-1}$  for P, and  $41.17 \text{ kg ha}^{-1}$  for K) Similarly, studies by Singh et al. (2017)

#### 4.3.2 Effect of weed management practices on nutrient uptake by crop at harvest

The data in Table 5 explains the impact of various weed management treatments on the nutrient uptake (N, P and K) by the crop at the harvest stage. The pre-emergence application of pendimethalin at  $0.75 \text{ kg ha}^{-1}$  combined with an early post-emergence (EPOE) application of imazethapyr at  $0.050 \text{ kg ha}^{-1}$  on 15-20 DAS (T4) resulted in the highest nutrient uptake by the crop, with values of  $207.17 \text{ kg ha}^{-1}$  for nitrogen (N),  $16.98 \text{ kg ha}^{-1}$  for phosphorus (P), and  $90.06 \text{ kg ha}^{-1}$  for potassium (K). This was followed by the treatment (T5) with PE pendimethalin at  $0.75 \text{ kg ha}^{-1}$  + EPOE quizalofop ethyl at  $0.075 \text{ kg ha}^{-1}$  on 15-20 DAS ( $182.23 \text{ kg ha}^{-1}$  of N,  $16.00 \text{ kg ha}^{-1}$  of P and  $84.08 \text{ kg ha}^{-1}$  of K) and (T2) PE pendimethalin at  $1.00 \text{ kg ha}^{-1}$  + hand weeding on 30 DAS ( $173.78 \text{ kg ha}^{-1}$  of N,  $15.11 \text{ kg ha}^{-1}$  of P and  $80.88 \text{ kg ha}^{-1}$  of K). In contrast, the unweeded check (T12) exhibited the lowest nutrient uptake, with values of  $101.25 \text{ kg ha}^{-1}$  for N,  $6.00 \text{ kg ha}^{-1}$  for P, and  $50.69 \text{ kg ha}^{-1}$  for K, followed by the treatment with pre-emergence application of oxyfluorfen at  $0.250 \text{ kg ha}^{-1}$  (T6), which showed nutrient uptake values of  $110.22 \text{ kg ha}^{-1}$  for N,  $6.92 \text{ kg ha}^{-1}$  for P, and  $54.08 \text{ kg ha}^{-1}$  for K. These results align with findings by Olayinka and Etejere (2015), reported that integrated weed management using herbicides enhances RGR by reducing weed

density, thereby allowing crops to access more light, nutrients, and water.

#### 4.3.3 Effect of weed management practices on nutrient uptake by weed at 60 DAS

The data Table 5 illustrates the impact of various weed management treatments on the nutrient uptake (N, P and K) by weeds at 60 days after sowing. The pre-emergence application of pendimethalin at 0.75 kg ha<sup>-1</sup> combined with an early post-emergence (EPOE) application of imazethapyr at 0.050 kg ha<sup>-1</sup> on 15-20 DAS (T4) resulted in the lowest nutrient uptake by weeds, with values of 1.62 kg ha<sup>-1</sup> for nitrogen (N), 0.10 kg ha<sup>-1</sup> for phosphorus (P) and 1.39 kg ha<sup>-1</sup> for potassium (K). This was closely followed by the treatment with PE pendimethalin at 0.75 kg ha<sup>-1</sup> + EPOE quizalofop ethyl at 0.075 kg ha<sup>-1</sup> on 15-20 DAS (T5), which recorded weed nutrient uptake values of 1.85 kg ha<sup>-1</sup> for N, 0.18 kg ha<sup>-1</sup> for P, and 1.66 kg ha<sup>-1</sup> for K and (T2) PE pendimethalin at 1.00 kg ha<sup>-1</sup> + hand weeding on 30 DAS with weed nutrient uptake values of 2.09 kg ha<sup>-1</sup> for N, 0.21 kg ha<sup>-1</sup> for P, and 1.92 kg ha<sup>-1</sup> for K. In contrast, the unweeded check (T12) exhibited the highest nutrient uptake by weeds, with values of 5.73 kg ha<sup>-1</sup> for N, 0.51 kg ha<sup>-1</sup> for P, and 3.61 kg ha<sup>-1</sup> for K. This was followed by the treatment with pre-emergence application of oxyfluorfen at 0.250 kg ha<sup>-1</sup> (T6), which showed weed nutrient uptake values of 5.51 kg ha<sup>-1</sup> for N, 0.46 kg ha<sup>-1</sup> for P, and 3.38 kg ha<sup>-1</sup> for K. These results align with findings by Olayinka and Etejere (2015), reported that integrated weed management using herbicides enhances RGR by reducing weed density, thereby allowing crops to access more light, nutrients, and water.

#### 4.3.4 Effect of weed management practices on nutrient uptake by weed at harvest

The impact of various weed management treatments on the nutrient uptake (N, P, and K) by weeds at the harvest stage is depicted in Table 5. The lowest nutrient uptake by weeds was observed in the treatment (T4) involving the pre-emergence application of pendimethalin at 0.75 kg ha<sup>-1</sup> combined with an early post-emergence (EPOE) application of imazethapyr at 0.050 kg ha<sup>-1</sup> on 15-20 DAS, with values of 2.12 kg ha<sup>-1</sup> for nitrogen (N), 0.21 kg ha<sup>-1</sup> for

phosphorus (P), and 2.01 kg ha<sup>-1</sup> for potassium (K). This was followed by treatment (T5), which involved PE pendimethalin at 0.75 kg ha<sup>-1</sup> + EPOE quizalofop ethyl at 0.075 kg ha<sup>-1</sup> on 15-20 DAS, resulting in weed nutrient uptake values of 2.40 kg ha<sup>-1</sup> for N, 0.35 kg ha<sup>-1</sup> for P, and 2.27 kg ha<sup>-1</sup> for K and treatment (T2) with PE pendimethalin at 1.00 kg ha<sup>-1</sup> + hand weeding on 30 DAS, which showed weed nutrient uptake values of 2.69 kg ha<sup>-1</sup> for N, 0.40 kg ha<sup>-1</sup> for P, and 2.48 kg ha<sup>-1</sup> for K. Conversely, the unweeded check (T12) exhibited the highest nutrient uptake by weeds, with values of 6.70 kg ha<sup>-1</sup> for N, 0.97 kg ha<sup>-1</sup> for P, and 5.47 kg ha<sup>-1</sup> for K. This was followed by the treatment with a pre-emergence application of oxyfluorfen at 0.250 kg ha<sup>-1</sup> (T6), which showed weed nutrient uptake values of 6.32 kg ha<sup>-1</sup> for N, 0.90 kg ha<sup>-1</sup> for P, and 4.72 kg ha<sup>-1</sup> for K. Similar findings by Yernaidu et al. (2023) support that effective weed control enhances mustard growth by allowing more efficient resource utilization, ultimately improving yield potential.

## 5. CONCLUSION

The pre-emergence application of pendimethalin at 0.75 kg ha<sup>-1</sup> combined with early post-emergence imazethapyr at 0.050 kg ha<sup>-1</sup> had maximum values of physiological parameters compared with other treatments at 60-90 DAS and 60-harvest stage. Early-season weed control is particularly important, as groundnut is most susceptible to weed competition during the first 4-6 weeks after sowing. Imazethapyr and Quizalofop are both systemic, selective post-emergence herbicides used to control weeds. Imazethapyr is absorbed by both the foliage and the root system, while Quizalofop is primarily absorbed through the foliage and then translocated to the root system.

## DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that not using any generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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