E-ISSN: 2618-0618
P-ISSN: 2618-060X

NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; 8(12): 267-270
Received: 23-10-2025
Accepted: 25-11-2025

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Evaluating the efficacy of tank-mix herbicides on weed growth and yield parameters in groundnut (*Arachis hypogaea* L.)

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DOI: https://www.doi.org/10.33545/2618060X.2025.v8.i12d.4379

Abstract
A field study was carried out on sandy loam soils at College Farm, Agricultural College, Mahanandi during *kharif*, 2024 to assess the efficacy of herbicide mixtures on weed growth and yield attributes of groundnut (*Arachis hypogaea* L.). The experiment comprised of ten weed management practices and laid out in randomized block design with three replications. The findings showed that significantly lower weed density and higher weed control efficiency were recorded with hand weeding twice at 20 and 40 DAS and it was closely followed by pre-emergence application of diclosulam 20 g/ha+ pendimethalin 680 g/ha *fb* hand weeding at 40 DAS. More no. of pods plant^{-1}, No. of kernels pod^{-1}, pod weight plant^{-1} and net returns were recorded with hand weeding twice at 20 and 40 DAS which was at par with pre-emergence application of diclosulam 20 g/ha + pendimethalin 680 g/ha *fb* hand weeding at 40 DAS.

Keywords: Diclosulam, groundnut, hand weeding. herbicide, pendimethalin

Introduction
Groundnut (*Arachis hypogaea*), is an important oilseed and leguminous crop grown in tropical and subtropical regions worldwide. It is called the king of oilseeds because of having valuable sources of nutrients including proteins, oil and vitamins. It contains 48-50% of oil, 26-28% of protein and essential vitamins & minerals. Globally, China leads in groundnut production with 19.27 million tonnes, followed by India with 10.30 million tonnes. In India, the key groundnut producing states include Gujarat, Rajasthan, Andhra Pradesh, Karnataka, and Tamil Nadu. Among the states, Gujarat is leading in groundnut production with 52.25 lakh tonnes followed by Rajasthan (21.27 lakh tonnes), Madhya Pradesh (14.35 lakh tonnes), Tamil Nadu (4.46 lakh tonnes), Uttar Pradesh (4.29 lakh tonnes) and Telangana (0.23 lakh tonnes). There are various reasons for low production, weed is one of the biggest concerns in groundnut cultivation. Depending on the kind, density, and length of the weed infestation, weeds can cause a yield loss of 13-85% by competing with crops for all available resources. Currently many formulations of pre-emergence and post emergence herbicides are available in the market which enables broad range weed control. Therefore, it is vital to evaluate how well herbicides suppress weeds, groundnut growth, and yield. Keeping all the above issues in mind, the present experiment was carried out using tank mixing of different pre-emergence and post-emergence herbicides or in combination with hand weeding or usage of herbicide alone in groundnut.

Materials and Methods
A field experiment was performed during *kharif*, 2024 at Agricultural College Farm, Mahanandi. The soil was sandy loam in texture, neutral in soil reaction (7.43), with low organic carbon (0.42%), low in available nitrogen (169 kg/ha), medium in available phosphorous (38 kg/ha) and high in available potassium (572 kg/ha). The trial was laid out in randomized block design with three replications. There were ten treatments (weed management practices), includes diclosulam 84% WDG 20 g/ha + pendimethalin 38.7% CS 680 g/ha, pyroxasulfone 85%WG 147 g/ha + pendimethalin 38.7% CS 680 g/ha, diclosulam 84% WDG 20 g/ha + pyroxasulfone 85%WG 147 g/ha, pendimethalin 38.7% CS 680 g/ha + quizalofop ethyl 10% EC 45 ml/ha,

pendimethalin 38.7% CS 680 g/ha alone, diclosulam 84% WDG 20 g/ha + pendimethalin 38.7% CS 680 g/ha followed by hand weeding at 40 DAS, pyroxasulfone 85%WG 147 g/ha + pendimethalin 38.7% CS 680 g/ha followed by hand weeding at 40 DAS, diclosulam 84% WDG 20 g/ha + pyroxasulfone 85%WG 147 g/ha followed by hand weeding at 40 DAS, hand Weeding twice at 20 and 40 DAS, control (un weeded). Pre-emergence herbicides (diclosulam, pendimethalin, pyroxasulfone) were applied uniformly at 3 DAS and post-emergence herbicide (quizalofop ethyl) was applied uniformly at 20 DAS, by using spray fluid 500 L/ha with the help of knap sack sprayer as per the treatments. Groundnut variety 'TCGS-1694' was sown by adopting spacing of 30 x 10 cm. Recommended dose of fertilizers 20:40:60 kg/ha N, P_2O_5 and K_2O was applied through urea, SSP and MOP. Entire quantity of nitrogen and potassium was applied in two splits *i.e.,* at basal and at flowering stage and full amount of phosphorous were applied as basal as per the treatments. Sulphur was applied in the form of gypsum 500 kg/ha at 45 DAS. Density and dry weight of weeds in groundnut were recorded at 30, 60, 90 DAS. Weed data was transformed to square root transformation ($\sqrt{X} + 0.5$) to normalize their distribution. For calculating weed control efficiency, standard formula was used. For the purpose of comparing various treatment means, the critical difference was correlated at 5 per cent significance level as recommended by Panse and Sukhatme (1985) [7].

Effect on weeds

Weed flora

The predominant weed species observed in the study area were *Cynodon dactylon*, *Dactylotenium aegyptium*, *Eragrostis curvula*, *Cyperus iria* and *Cyperus rotundus* in monocot category and *Amaranthus viridis*, *Boerhavia diffusa*, *Commelina bengalensis*, *Digera arvensis*, *Parthenium hysterophorus*, *Phyllanthus niruri* and *Trichodesma indicum* in broad-leaved weeds category are showed their dominance and competitiveness in groundnut.

Weed density

Various weed management techniques used in the study had a significant impact on weed density at different growth stages *viz.*,30, 60, 90 DAS (Table 1).

At 30 DAS, hand weeding twice at 20 and 40 DAS (T_9) recorded the lowest density of weeds which was comparable with pre-emergence application of diclosulam + pendimethalin *fb* hand weeding at 40 DAS (T_6), pre-emergence application of diclosulam + pyroxasulfone *fb* hand weeding at 40 DAS (T_8), pre-emergence application of diclosulam + pendimethalin (T_1) and pre-emergence application of diclosulam + pyroxasulfone (T_3). Because diclosulam offers broad-spectrum weed control, herbicide combinations with it are excellent at controlling weeds in their early stages. When used before emergence, they perform very well. The results are consistent with the research Meena *et al.* (2021) [5]. At 60 and 90 DAS lower weed density was recorded with hand weeding twice at 20 and 40 DAS (T_9) which was similar to pre-emergence application of diclosulam + pendimethalin *fb* by hand weeding at 40 DAS (T_6) and diclosulam + pyroxasulfone *fb* hand weeding at 40 DAS (T_8). The decreased in weed density was seen with pre-emergence application of diclosulam 84% WDG 20 g/ha might be due to the inhibition of the enzyme Acetolactate Synthase (ALS), which is essential for the synthesis of amino acids. The treatments having pendimethalin as one of the components have shown their effectiveness against grassy and broad-leaved weeds and have successfully reduced the density of these main weed species at the study site. The application of diclosulam 0.9% + pendimethalin 35% SE ready mixture at the lowest dose 18 + 700 g/ha as pre plant incorporation at 30 DAS caused appreciable reduction in density. These findings coincide with the findings of Gulaiya *et al.* (2023) [2] and Mukilan *et al.* (2023) [6]. Maximum weed density was observed in un weeded check.

Weed dry weight

Weed dry weight at different growth stages of crop *viz.*, 30, 60 and 90 DAS was significantly influenced by different weed management techniques during the study (Table 2).

At 30 DAS, hand weeding twice at 20 and 40 DAS (T_9) recorded lower dry weight of weeds which was comparable with pre-emergence application of diclosulam + pendimethalin *fb* hand weeding at 40 DAS (T_6), pre-emergence application of diclosulam + pyroxasulfone *fb* hand weeding at 40 DAS (T_8), pre-emergence application of diclosulam + pendimethalin (T_1) and pre-emergence application of diclosulam + pyroxasulfone (T_3). Because diclosulam offers broad-spectrum weed control, herbicide combinations with it are excellent at controlling weeds in their early stages. The results are consistent with the research Meena *et al.* (2021) [5]. At 60 and 90 DAS lower weed dry weight was recorded with hand weeding twice at 20 and 40 DAS (T_9) which was similar to pre-emergence application of diclosulam + pendimethalin *fb* by hand weeding at 40 DAS (T_6) and diclosulam + pyroxasulfone *fb* hand weeding at 40 DAS (T_8). Diclosulam and pendimethalin together suppress weeds by preventing amino acid synthesis, interfering with enzyme function and blocking weed growth. These results are consistent with Gulaiya *et al* (2023) [2].

Weed control efficiency (WCE)

Weed control efficiency recorded at different growth stages of crop was significantly and progressively influenced by different weed management practices (Table 3).

At 30 DAS higher weed control efficiency was observed with hand weeding twice at 20 and 40 DAS(T_9), which was at par with pre-emergence application of diclosulam 20 g/ha + pendimethalin 680 g/ha *fb* hand weeding at 40 DAS (T_6), pre-emergence application of diclosulam + pyroxasulfone *fb* hand weeding at 40 DAS (T_8), pre-emergence application of diclosulam + pendimethalin (T_1) and pre-emergence application of diclosulam + pyroxasulfone (T_3). At 60 and 90 DAS higher weed control efficiency was recorded with hand weeding twice at 20 and 40 DAS (T_9) which was similar to pre-emergence application of diclosulam + pendimethalin *fb* by hand weeding at 40 DAS (T_6). Pre-emergence application of diclosulam 20 g/ha resulted in higher weed control efficiency which may be because of herbicide mixtures containing diclosulam are very effective at suppressing weeds and it provides a broad spectrum weed control. Treatments including pendimethalin have shown their effectiveness against grassy and broad-leaved weeds, hence increasing the effectiveness of weed control. These results were consistent with the findings of Goud *et al.* (2023) [1]. Revealing that diclosulam offers a greater reduction of grasses, sedges and broad-leaved weeds.

Effect on yield attributes

Number of pods plant^{-1}

Number of pods plant^{-1} of groundnut significantly influenced by different methods of weed control (Table 4). Hand weeding twice at 20 and 40 DAS (T_9) significantly recorded more no. of pods plant^{-1}, however, which was on par with pre-emergence

application of diclosulam + pendimethalin *fb* hand weeding at 40 DAS (T_6) and pre-emergence application of diclosulam + pyroxasulfone *fb* hand weeding at 40 DAS (T_8). A healthier environment with more uptake of macro and micro nutrients and the eventual formation of big sink due to less crop weed competition may be the cause of the rise in pods plant^{-1}. Similar results were confirmatory with the findings Kundu *et al.* (2021) [4] and Gulaiya *et al.* (2023) [2].

No of kernels pod^{-1}

The number of kernels pod^{-1} in groundnut was found non-significant by different weed management practices tested (Table 4). However, the treatments with combined application of herbicides along with hand weeding at 40 DAS recorded numerically slightly higher number of kernels pod^{-1} might be due to adequate supply of nutrients during the entire crop growing period.

Pod weight plant^{-1} (g)

Pod weight plant^{-1} of groundnut was significantly influenced by the different weed measures of weed control (Table 4).

Among the different weed management practices evaluated, hand weeding twice at 20 and 40 DAS (T_9) significantly recorded highest pod weight plant^{-1}, however, which was on par with pre-emergence application of diclosulam + pendimethalin *fb* hand weeding at 40 DAS (T_6), Pre-emergence application of diclosulam + pyroxasulfone *fb* hand weeding at 40 DAS (T_8). It is due to less competition from weeds, gives the crop greater access to resources like sunlight, water and nutrients. Enhanced availability of resources may result in higher biomass accumulation and as a result, larger pods. Similar findings were observed by Honnali and Satihal (2021) [3]. Due to intense crop weed competition and decreased nutrient uptake by crop, un weeded check and herbicide application alone (without hand weeding) produced lower pod weight plant^{-1}.

Economics (₹ ha^{-1})

In this present trial, Net returns were significantly influenced by different weed management practices of groundnut (Table 5). Higher net returns were observed with hand weeding twice at 20 and 40 DAS (T_9), which was comparable with pre-emergence application of diclosulam + pendimethalin *fb* hand weeding at 40 DAS (T_6). It could be the result of increased agricultural output at lower cultivation costs. These outcomes are consistent with the findings of Subramanyam *et al.* (2020) [8].

Table 1: Weed density (No. m^2) as influenced by different weed management practices at various growth stages of groundnut

Treatments	30 DAS	60 DAS	90 DAS
T_1**:** Diclosulam 20 g/ha + pendimethalin 680 g/ha	17.67 (4.26)	73.67 (8.61)	98.67 (9.96)
T_2: Pyroxasulfone147 g/ha + pendimethalin 680 g/ha	43.67 (6.65)	111.33 (10.57)	134.33 (11.61)
T_3: Diclosulam 20 g/ha + pyroxasulfone 147 g/ha	26.00 (5.15)	90.33 (9.53)	119.00 (10.93)
T_4: Pendimethalin 680 g/ha + quizalofop ethyl 45 ml/ha	74.00 (8.63)	123.67 (11.14)	158.33 (12.60)
T_5: Pendimethalin 680 g/ha alone	90.00 (9.51)	142.66 (11.96)	183.33 (13.55)
T_6: Diclosulam 20 g/ha + pendimethalin 680 g/ha *fb* hand weeding at 40 DAS	15.33 (3.98)	43.67 (6.65)	60.33 (7.79)
T_7: Pyroxasulfone 147 g/ha + pendimethalin 680 g/ha *fb* hand weeding at 40 DAS	35.33 (5.98)	66.33 (8.17)	90.33 (9.53)
T_8: Diclosulam 20 g/ha + pyroxasulfone 147 g/ha *fb* hand weeding at 40 DAS	23.67 (4.92)	56.33 (7.54)	75.67 (8.72)
T_9: Hand Weeding twice at 20 and 40 DAS	8.33 (2.97)	26.67 (5.21)	40.67 (6.41)
T_{10}: control (un weeded)	121.00 (11.02)	167.67 (2.97)	209.17 (14.46)
S.Em±	1.50	3.00	3.60
CD (P=0.05)	4.50	8.80	10.60
CV (%)	5.71	5.69	5.26

*Figures in parenthesis indicates squares root transformed ($\sqrt{X}$ + 0.5) values.

Table 2: Weed dry weight (g m^{-2}) as influenced by different weed management practices at various growth stages of groundnut

Treatments	30 DAS	60 DAS	90 DAS
T_1: Diclosulam 20 g/ha + pendimethalin 680 g/ha	10.83 (3.36)	59.70 (7.76)	206.96 (14.40)
T_2: Pyroxasulfone147 g/ha + pendimethalin 680 g/ha	26.93 (5.24)	87.50 (9.38)	256.70 (16.03)
T_3: Diclosulam 20 g/ha + pyroxasulfone 147 g/ha	15.62 (4.01)	72.71 (8.56)	233.38 (15.29)
T_4: Pendimethalin 680 g/ha + quizalofop ethyl 45 ml/ha	46.49 (6.85)	104.22 (10.23)	280.99 (16.77)
T_5: Pendimethalin 680 g/ha alone	61.04 (7.84)	119.19 (10.94)	319.93 (17.90)
T_6: Diclosulam 20 g/ha + pendimethalin 680 g/ha *fb* hand weeding at 40 DAS	9.19 (3.11)	31.64 (5.67)	108.54 (10.44)
T_7: Pyroxasulfone 147 g/ha + pendimethalin 680 g/ha *fb* hand weeding at 40 DAS	20.40 (4.57)	52.53 (7.28)	181.59 (13.49)
T_8: Diclosulam 20 g/ha + pyroxasulfone 147 g/ha *fb* hand weeding at 40 DAS	13.24 (3.71)	41.68 (6.49)	162.68 (12.77)
T_9: Hand Weeding twice at 20 and 40 DAS	5.27 (2.40)	17.85 (4.28)	71.24 (8.47)
T_{10}: control (un weeded)	76.45 (8.77)	140.70 (11.83)	349.67 (18.71)
S.Em±	1.00	2.40	7.70
CD (P=0.05)	3.10	7.20	22.80
CV (%)	6.25	5.79	6.14

*Figures in parenthesis indicates squares root transformed ($\sqrt{X}$ + 0.5) values.

Table 3: Weed control efficiency (%) as influenced by different weed management practices at various growth stages of groundnut

Treatments	30 DAS	60 DAS	90 DAS
T_1: Diclosulam 20 g/ha + pendimethalin 680 g/ha	85.42	56.11	52.79
T_2: Pyroxasulfone147 g/ha + pendimethalin 680 g/ha	63.91	33.69	35.61
T_3: Diclosulam 20 g/ha + pyroxasulfone 147 g/ha	78.56	46.15	43.25
T_4: Pendimethalin 680 g/ha + quizalofop ethyl 45 ml/ha	38.84	26.27	24.18
T_5: Pendimethalin 680 g/ha alone	25.67	14.93	12.22

T_6: Diclosulam 20 g/ha + pendimethalin 680 g/ha *fb* hand weeding at 40 DAS	87.33	73.98	71.13
T_7: Pyroxasulfone 147 g/ha + pendimethalin 680 g/ha *fb* hand weeding at 40 DAS	70.89	60.42	56.78
T_8: Diclosulam 20 g/ha + pyroxasulfone 147 g/ha *fb* hand weeding at 40 DAS	80.42	66.45	63.72
T_9: Hand Weeding twice at 20 and 40 DAS	93.15	84.14	80.59
T_{10}: control (un weeded)	0.00	0.00	0.00
S.Em±	2.40	2.00	1.90
CD (P=0.05)	7.20	5.80	5.50
CV (%)	6.76	7.36	7.34

Table 4: Yield attributes of groundnut as influenced by different weed management practices

Treatments	No. of pods Plant^{-1}	No. of kernels Pod^{-1}	Pod weight Plant^{-1}
T_1: Diclosulam 20 g/ha + pendimethalin 680 g/ha	32.1	1.9	4.9
T_2: Pyroxasulfone147 g/ha + pendimethalin 680 g/ha	31.1	1.9	4.4
T_3: Diclosulam 20 g/ha + pyroxasulfone 147 g/ha	31.6	1.9	4.6
T_4: Pendimethalin 680 g/ha + quizalofop ethyl 45 ml/ha	30.3	1.8	4.1
T_5: Pendimethalin 680 g/ha alone	29.6	1.8	3.9
T_6: Diclosulam 20 g/ha + pendimethalin 680 g/ha *fb* hand weeding at 40 DAS	33.7	1.9	5.5
T_7: Pyroxasulfone 147 g/ha + pendimethalin 680 g/ha *fb* hand weeding at 40 DAS	32.8	1.9	5.2
T_8: Diclosulam 20 g/ha + pyroxasulfone 147 g/ha *fb* hand weeding at 40 DAS	33.1	1.9	5.4
T_9: Hand Weeding twice at 20 and 40 DAS	34.2	2.0	5.9
T_{10}: control (un weeded)	29.1	1.8	3.8
S.Em±	1.10	0.10	0.20
CD (P=0.05)	3.3	NS	0.5
CV (%)	6.10	5.09	5.43

Table 5: Net returns of groundnut as influenced by different weed management practices

Treatments	Net returns (₹ ha^{-1})
T_1: Diclosulam 20 g/ha + pendimethalin 680 g/ha	31747
T_2: Pyroxasulfone147 g/ha + pendimethalin 680 g/ha	21179
T_3: Diclosulam 20 g/ha + pyroxasulfone 147 g/ha	24743
T_4: Pendimethalin 680 g/ha + quizalofop ethyl 45 ml/ha	21175
T_5: Pendimethalin 680 g/ha alone	20209
T_6: Diclosulam 20 g/ha + pendimethalin 680 g/ha *fb* hand weeding at 40 DAS	42831
T_7: Pyroxasulfone 147 g/ha + pendimethalin 680 g/ha *fb* hand weeding at 40 DAS	30016
T_8: Diclosulam 20 g/ha + pyroxasulfone 147 g/ha *fb* hand weeding at 40 DAS	36124
T_9: Hand Weeding twice at 20 and 40 DAS	48176
T_{10}: control (un weeded)	18832
S.Em±	1120.6
CD (P=0.05)	3329.4

Conclusion

From the above results, it can be concluded that lower weed density and dry weight, greater weed control efficiency, more no. of pods plant^{-1}, kernels pod^{-1}, pod weight plant^{-1} and net returns was obtained with hand weeding twice at 20 and 40 DAS (T_9), which was on par with pre-emergence application of diclosulam 20 g/ha + pendimethalin 680 g/ha followed by hand weeding at 40 DAS (T_6)were considered to be the most effective, economically viable and environmentally friendly integrated weed management practices for enhancing the productivity and maximizing the profitability of groundnut in sandy loam soils of Scarce Rainfall Zone of Andhra Pradesh

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