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RESEARCH ARTICLE

Optimizing groundnut production through diclosulam-based weed management and their residual influence on the wheat crop

M.L. Mehriya*, Sarita and Surendra Kumar

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ABSTRACT

An experiment was conducted at Agricultural Research Station, Mandor during two consecutive rainy (*Kharif*) seasons of 2021 and 2022 and subsequent *Rabi* season of 2021-22 and 2022-23 to optimize groundnut (*Arachis hypogaea* L.) production through diclosulam-based weed management and its residual effect on consecutive wheat crop. The findings disclosed that all the weed management treatment significantly reduced weed density and weed dry matter at 50 days after sowing (DAS) and increased yield attributes and pod yield of groundnut over weedy check. The highest weed control efficiency (WCE) was observed in thrice manual weeding at 25, 50 and 80 DAS/weed free (84.0%) followed by (*fb*) application of diclosulam 25 g/ha pre-emergence (PE) *fb* hand weeding at 30 and 60 DAS (79.2%). The maximum pod yield (2.03 t/ha) was recorded due to thrice hand weeding at 25, 50 and 80 DAS/weed free, which was at par with diclosulam 25 g/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS, pendimethalin 1.0 kg/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS, diclosulam 25 g/ha PE *fb* hand weeding at 30 and 60 DAS and diclosulam 20 g/ha *fb* hand weeding at 30 and 60 DAS. Results further indicate that highest net returns and B: C ratio were recorded in pendimethalin1.0 kg/ha PE + quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS followed by diclosulam 25 g/ha PE + quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS.

Keywords: Diclosulam, Groundnut, Pendimethalin, Productivity, Weed dynamics

INTRODUCTION

Groundnut, scientifically known as *Arachis hypogaea* L., is a leguminous plant cultivated extensively in tropical and subtropical regions, typically within latitudes 40°N and 40°S, and is highly prized for its high-oil content and edible seeds. On a global scale, groundnut holds significant importance, ranking fourth among major sources of edible oil. Worldwide, groundnut cultivation spans a vast area of 32.7 m ha, yielding 53.9 m t with a productivity of 1648 kg/ha (Anon. 2021). India, a prominent groundnut-growing nation, takes a leading position with a cultivation area of 4.96 m ha, making it the second-largest producer globally. In the 2022-23 season, India produced 10.30 m t of groundnut with a productivity of 2075 kg/ha (Anon. 2023).

Weeds present a significant challenge to groundnut production during the early growth stages, particularly up to 40 DAS, due to the slow initial growth of groundnut and compact, underground pod-bearing nature. This leads to intense competition with weeds for essential resources such as water, nutrients, sunlight, and space, resulting in yield losses ranging from 17-85% in rainy (*Kharif)* season groundnut crops (Shwetha *et al*. 2016). Effective weed management during the critical crop-weed competition period (40-60 DAS) is crucial to achieve higher pod yields per hectare. While manual weeding is effective, it is characterized by labour-intensiveness, time consumption, and significant costs, especially within the Indian context (Prajapati *et al.* 2015). Delaying weed control can result in decreased economic yields, compromised product quality, and increased vulnerability to diseases and pests. In such scenarios, herbicidal applications offer a practical solution for weed management (Nainwal *et al*. 2010). Pendimethalin and oxyfluorfen are currently common pre-emergence herbicides used in groundnut and other crops (Jat *et al.* 2011), but they face limitations in controlling broad-leaved weeds. Therefore, there is a requirement to explore alternative chemicals for effective management of weed. This study investigates the efficacy of diclosulam 84% WDG, a new herbicide, for pre-emergence weed control in groundnut. Diclosulam, a triazolopyrimidine sulphonamide herbicide, is part of the new generation of low-dose, high-efficiency herbicides that inhibit acetolactate synthase (ALS), halting cell division (Singh *et al.* 2009) and weed growth with lower toxicity to mammals compared to high-volume herbicides like pendimethalin. Pre-emergence herbicides are used to manage early-stage weeds but may allow weed emergence at later stages, while post-emergence herbicides are recommended

Agricultural Research Station, Mandor, Agriculture University, Jodhpur, Rajasthan 342304, India

* Corresponding author email: mlmehriya@gmail.com

for later-stage weed control (Singh *et al*. 2023). However, there is limited research on the integrated application of PE and PoE herbicides for groundnut weed management. This study aims to identify suitable herbicides, either alone or in combination, for effective weed management in groundnut cultivation, with a specific focus on diclosulam as a potential alternative. The study assesses diclosulam's effectiveness in weed control, its impact on groundnut yield, and its potential as a solution to the challenges posed by weed infestations in groundnut cultivation.

MATERIALS AND METHODS

The field experiment was carried out at Agricultural Research Station, Mandor-Jodhpur, Rajasthan, India. Geographically, it is located between 26° 15' N to 26° 45' North latitude and 73° 00' E to 73° 29' East longitude at an altitude of 231 meters above mean sea level. This region falls under agro-climatic zone Ia (Arid Western Plains Zone) of Rajasthan.

The soil at the experimental site was sandy loam in texture, with pH of 8.2 and organic carbon content of 0.13, indicating the presence of limited organic matter. Additionally, the soil contained 174 kg/ha of available nitrogen, 22 kg/ha of available phosphorus, 325 kg/ha of available potassium, and 9.24 mg S/kg of soil. The periodical means weekly weather parameters for the period of the experimentation recorded from the Meteorological Observatory of Agricultural Research Station, Mandor-Jodhpur and are presented in figure 1.0. The mean daily minimum and maximum temperatures varied between 23 to 30.8°C and 29.1 to 38.6°C, respectively in 2021 and the corresponding values in the year 2022 were 19.1 to 29.6°C and 29.2 to 40.4°C during the crop growing seasons. The average daily relative humidity fluctuated between 58.6 to 75.2% in 2021 and 56.5 to 71.0% in 2022. Groundnut variety '*HNG*-123' (bunchy type) was manually sown on June 27, 2021, and June 25, 2022, using a seed rate of 80 kg/ha, with row to row spacing of 30 cm and plant to plant spacing of 10 cm. There were ten treatments used in the experiment, namely: diclosulam 20 g/ha PE; diclosulam 25 g/ha PE; pendimethalin 1.0 kg/ha PE; diclosulam 20 g/ha PE *fb* hand weeding at 30 and 60 DAS; diclosulam 25 g/ha PE *fb* hand weeding at 30 and 60 DAS; diclosulam 20 g/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS; diclosulam 25 g/ha PE *fb quizalofop*-ethyl 50 g/ha PoE at 30 and 60 DAS; pendimethalin 1.0 kg/ha PE *fb* quizalofop-ethyl 50 g/ha (PoE) at 30 and 60 DAS; hand weeding thrice at 25, 50 and 80 DAS/weed free check; weedy check. In the experiment, each treatment occupied an 18 m² plot (5 x 3.6 m²) arranged with three replications in a randomized block design (RBD), and herbicides were applied by knapsack sprayer using a flat fan nozzle at a water volume of 600 L/ha. Groundnut cultivation involved the application of 15, 60 and 250 kg/ha nitrogen, phosphorus and gypsum, respectively with the full dose of nitrogen and phosphorus were applied at sowing and gypsum was applied in two equal doses at sowing and during earthing up at 40 DAS, respectively.

Key parameters such as shelling percentage, WCE, and weed index (WI) were calculated using standard formulas. Shelling percentage reflects the ratio of seed weight to total pod weight. Total weed density/m² and weed dry weight in g/m² were recorded at 25 and 50 DAS. A quadrate of size 0.5 m x 0.5 m (0.25 m²) was used to measure weed density and biomass. To compare the data on weed density and biomass among treatments, the values were transformed using a square root transformation (sqrt (x+0.5)). A carry-over study evaluated the residual effects of diclosulam herbicide, previously used in groundnut cultivation, on the succeeding wheat crop. Wheat variety '*GW 11*' was grown in fixed plots with a row spacing of 22.5 cm. Observations were conducted on germination and yield, and the wheat crop received necessary irrigation and fertilization throughout its growth period. Phytotoxicity signs were monitored, and at crop maturity, yield parameters and overall crop yield were assessed. The experimental data, acquired from multiple observations, underwent statistical analysis using the 'Analysis of Variance' (ANOVA) method. Pooled mean values derived from three replications per year were analyzed, following the approach outlined by Panse and Sukhatme (1985). The Least Significant Difference (LSD) was computed to facilitate treatment comparisons, whenever the variance ratio (F test) exhibited significance at the 5% probability level.

RESULTS AND DISCUSSION

Effect on weed flora

The experimental plot was predominantly infested with broad-leaved weeds such as *Amaranthus viridis, Celosia argentea, Corchorus trilocularis*, *Digera arvensis, Phyllanthus niruri, Portulaca oleracea* and *Tribulus terristris* and grassy weeds like *Cynodon dactylon*, *Dactyloctenium aegyptium* and *Eragrostis minor,* and sedge, specifically *Cyperus rotundus*. However, it was evident that broad-leaved weeds held dominance over grassy and sedge weeds. The occurrence and intensity of these weeds varied among different treatment plots. The intensity of weed infestation differed based on the application of different herbicides and manual weeding at various stages of crop growth. Mehriya *et al*. (2021) observed this weed flora in field of groundnut.

Effect on weeds

The data from **Table 1** reveals the impact of different herbicidal treatments on weed density, biomass, and weed control efficiency over two seasons. The hand weeding thrice at 25, 50 and 80 DAS treatment significant reduced total weed density over control and herbicidal treatments. Among the herbicidal treatments, the diclosulam 25 g/ha PE *fb* hand weeding at 30 and 60 DAS and diclosulam 25 g/ ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS, showed the significantly lower weed density and weed dry weight at 50 DAS. The treatment pendimethalin 1.0 kg/ha PE *fb* quizalofop-ethyl 50 g/ ha PoE at 30 and 60 DAS has reduced weed dry weight by approximately 76.95% compared to the weedy check. Conversely, the untreated control (weedy check) treatment exhibited highest total weed density and weed dry weight during both seasons. Treatment diclosulam 20 g/ha PE *fb* hand weeding at 30 and 60 DAS, diclosulam 25 g/ha PE *fb* hand weeding at 30 and 60 DAS, diclosulam 20 g/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS, diclosulam 25 g/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS and pendimethalin 1.0 kg/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS were found on par with each other in weed dry weight at 50 DAS. Highest weed control efficiency (84.0%) obtained in hand weeding thrice at 25, 50 and 80 DAS/weed free check followed by diclosulam 25 g/ha PE *fb* inter-cultivation at 30 and 60 DAS (79.4%) followed by treatment diclosulam 25 g/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS (78.2%), and pendimethalin 1.0 kg/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS (77.1%) and lowest weed index (4.4) was recorded with diclosulam 25 g/ha PE *fb* quizalofop-ethyl 50 g/ ha PoE at 30 and 60 DAS. Similar findings were also documented by Honnali and Satiha (2022). Musa *et al*. (2022) recorded that effective weed control and a higher groundnut pod yield were achieved through the pre-emergence application of diclosulam at a rate of 25 g/ha (PE) combined with imazethapyr at 100 g/ ha (PoE) at 18-20 DAS. This approach offers a viable alternative to the current recommendation of using pendimethalin 1.0 kg/ha (PE) along with imazethapyr 100 g/ha (PoE) at the same stage of 18-20 DAS. The increased weed control effectiveness observed in these treatments may be attributed to the decreased dry weight of weeds. Weed competition was notably diminished through the application of various weed control methods, with pre-emergence diclosulam use proving significantly superior to the other approaches (Musa *et al*., 2022). This superior efficacy extended to the management of all weed categories, including the most prevalent ones. The extended half-life of diclosulam, combined with its elevated leaching potential index, results in higher concentrations reaching deeper soil layers, effectively controlling not only sedges and broadleaf weeds but also necessitating a longer duration for the management of dicot weeds (Har N *et al*. 2020).

Effect on groundnut crop

All herbicidal treatments were significantly influenced growth and yield parameters of groundnut, *viz*. branches/plant, pods/plant, shelling (%), seed index (g), pods yield (t/ha) and haulms yield (t/ha) over weedy check (**Table 2** & **3**). Any phytotoxicity symptoms were not recorded during crop growing period. Maximum number of branches in groundnut were recorded under hand weeding thrice at 25, 50 and 80 DAS (7.3) followed by diclosulam 25 g/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS (6.8) and diclosulam 25 g/ha PE *fb* hand weeding at 30 and 60 DAS (6.8) which significantly increased number of branches over weedy check plot and diclosulam 20 g/ha PE. The treatment pendimethalin 1.0 kg/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS also significantly increased number of branches/plant in groundnut by 61.0% over weedy check. The significantly higher

Table 1. Effect of integrated weed management on weed dynamics of *Kharif* groundnut (pooled data of two years)

Treatment	Weed density (no./m^2)		Weed dry weight (g/m^2)		WCE (%) at 50 DAS	WI (%)
	25 DAS	50 DAS	25 DAS	50 DAS		
Diclosulam 20 g/ha PE	5.56 (32.3)	6.1 (37.5)	4.0 (15.9)	5.7 (32.9)	47.2	29.6
Diclosulam 25 g/ha PE	3.41 (11.6)	5.0 (25.5)	3.4 (11.5)	4.4 (19.8)	68.2	12.5
Pendimethalin 1.0 kg/ha PE	3.49 (12.2)	4.9 (24.3)	3.4 (11.7)	4.6 (20.9)	66.4	13.3
Diclosulam 20 g/ha *fb* hand weeding at 30 and 60 DAS	4.48 (20.2)	4.8 (23.3)	3.9 (15.0)	3.9 (14.9)	76.0	9.5
Diclosulam 25 g/ha PE *fb* hand weeding at 30 and 60 DAS	3.44 (11.9)	4.4 (19.7)	3.4 (11.9)	3.6 (12.8)	79.4	5.7
Diclosulam 20 g/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS	4.49 (20.2)	4.7 (23.5)	3.9 (15.2)	4.0 (17.3)	72.2	17.0
Diclosulam 25 g/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS	3.28 (10.8)	4.4 (19.8)	3.4 (11.3)	3.7 (13.6)	78.22	4.4
Pendimethalin 1.0 kg/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30&60 DAS	3.40 (11.6)	4.5 (20.5)	3.5 (12.1)	3.8 (14.3)	77.1	4.6
Hand weeding thrice at 25, 50 and 80 DAS/weed free check	7.42 (55.3)	3.5 (12.5)	4.9 (23.6)	3.2 (10.0)	84.0	0.0
Weedy check	7.65 (59.2)	8.3 (70.0)	4.9 (24.2)	7.9 (62.4)	0.00	52.9
LSD (p=0.05)	0.48	0.48	0.44	0.44		

Where, the original values enclosed in parentheses underwent a square-root transformation ($\sqrt{x+0.5}$) prior to being subjected to statistical analysis number of pods/plant (22.3) was observed in the hand weeding at 25, 50 and 80 DAS/weed free check plot. Among herbicides, application of diclosulam 25 g/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS (20.9) significantly increased pods/plant over diclosulam 20 g/ha PE, diclosulam 25 g/ha PE, pendimethalin 1.0 kg/ha PE, diclosulam 20 g/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS and weedy check plot. All treatments were significantly enhanced shelling % of groundnut over weedy check treatment and found non-significant with each other. The shelling % increased by 14.7% due to treatment pendimethalin 1.0 kg/ha PE *fb* quizalofop-ethyl 50 g/ ha PoE at 30 and 60 DAS. Maximum seed index was found in hand weeding thrice (50.6) followed by pendimethalin 1.0 kg/ha PE *fb* quizalofop-ethyl 50 g/ ha PoE at 30 and 60 DAS (49.2). Both these treatments have significantly increased seed index over remaining treatments. The highest pod and haulm yield were obtained under hand weeding thrice at 25, 50 and 80 DAS/weed free check (2.03 and 3.76 t/ha) followed by diclosulam 25 g/ha PE *fb* quizalofop-ethyl 50 g/ha (PoE) at 30 and 60 DAS (1.94 and 3.71 t/ha), pendimethalin 1.0 kg/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS (1.93 and 3.73 t/ha), diclosulam 25 g/ha PE *fb* hand weeding at 30 and 60 DAS (1.91 and 3.67 t/ha) and diclosulam 20 g/ha PE *fb* hand weeding at 30 and 60 DAS (1.84 and 3.51 t/ha) which were statistically at par with each other. Application of diclosulam 25 g/ha PE *fb* quizalofop-ethyl 50 g/ha (PoE) at 30 and 60 DAS and pendimethalin 1.0 kg/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS significantly increased pod yield by 102.0 and 101.0% over weedy plot. In a similar vein, Har N *et al*. (2020) also reported increased groundnut pod yield through pre-emergence application of diclosulam 26 g/ha. In a study, Singh *et al.* (2023) highlighted that the use of pre-emergence herbicide application followed by post-emergence herbicide application or hand weeding led to significantly improved yield components and overall crop yield. Whereas, significantly lower pod yield and seed index were recorded under weedy check and the highest were recorded under thrice hand weeding (**Table 2** and **3**). This could be attributed due to low crop-weed competition in this treatment. Honnali and Satihal (2022) recorded that the use of diclosulam 84% WDG at a rate of 26 g/ha proved highly effective in controlling weeds in groundnut crops. This treatment resulted in the highest pod yield, pod dry weight, and number of pods per plant, comparable to hand weeding at specific time points. Importantly, it did not adversely impact the germination, growth, or yield of subsequent sunflower crops.

Economics

The net returns (₹ 62816/-) and B: C (1.95) ratio were found maximum in application of pendimethalin 1.0 kg/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS followed by diclosulam 25 g/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS (62527 and 1.94), while lowest net return (₹ 2820/ha) and B: C ratio (1.05) were observed in the weedy check (**Table 3**). Among various weed management strategies; these results highlight the substantial impact of weed control on net returns. The lowest B:C ratio with weedy check and higher values with application of pre-emergence application of pendimethalin followed by post emergence application of herbicides at 20 to 30 days after sowing were also reported earlier by Har *et al.* (2020).

Table 2. Effect of integrated weed management on growth and yield attributes of *Kharif* groundnut (pooled data of two years)

Treatment	Phyto-toxicity rating (DAS- Days after spray)		Plant Population		No. of branches/ plant	No. of pods/ plant	Shelling (%)	Seed index (g)
	15 DAS	30 DAS	Initial	Final				
Diclosulam 20 g/ha PE	0	0	376	369	5.6	14.8	66.1	47.0
Diclosulam 25 g/ha PE	0	0	373	368	6.6	18.2	68.1	48.3
Pendimethalin 1.0 kg/ha PE	0	0	382	375	6.5	18.2	67.9	47.8
Diclosulam 20 g/ha *fb* hand weeding at 30 and 60 DAS	0	0	382	377	6.7	19.7	68.5	47.4
Diclosulam 25 g/ha PE *fb* hand weeding at 30 and 60 DAS	0	0	386	382	6.8	19.7	70.0	48.0
Diclosulam 20 g/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS	0	0	376	372	6.2	17.7	67.0	47.8
Diclosulam 25 g/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS	0	0	383	378	6.8	20.9	69.5	48.3
Pendimethalin 1.0 kg/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS	0	0	371	364	6.6	19.6	69.5	49.2
Hand weeding thrice at 25, 50 and 80 DAS/weed free check	0	0	380	373	7.3	22.3	71.0	50.6
Weedy check	0	0	378	368	4.1	8.9	60.6	43.4
LSD (p=0.05)			15.2	14.5	1.03	2.42	5.16	1.88

Where, the original values enclosed in parentheses underwent a square-root transformation ($\sqrt{x+0.5}$) prior to being subjected to statistical analysis

Correlation analysis

In the conducted correlation analysis, a comprehensive matrix was generated to assess the relationships between various agricultural parameters in the research study (**Figure 2**). The variables included weed density at both 25 days after sowing (DAS) and 50 DAS, as well as the corresponding dry weed weights. Additionally, the analysis considered plant attributes such as the number of branches and pods per plant, shelling percentage, seed index, and pod yield. The results reveal several noteworthy findings. Firstly, a strong positive correlation was observed between weed density at 25 DAS and weed dry weight at both 25 DAS with correlation coefficients of 0.989. Similarly, weed density at 50 DAS exhibited a positive correlation of 0.989 with weed dry weight at 50 DAS. Conversely, negative correlations were observed between weed density and several crop attributes, including branches, pods per plant, selling percentage, seed index, and pod yield. These correlations were particularly strong, with coefficients ranging from -0.91 to -0.98, suggesting that higher weed density is associated with lower values for these crop attributes.

Principal component analysis

Principal Component Analysis (PCA) was employed to explore the underlying structure of the dataset, which contains information related to weed density at 25 and 50 days after sowing, weed dry weight at the same time, number of branches, pods per plant, selling factors, seed index, and pod yield (**Figure 3**). The loadings of each variable on the principal components (PC1 to PC9) were also examined. These loadings represent the contribution of each variable to the principal components. Notably, PC1 showed the highest loadings for weed density at 50 DAS and weed dry weight at 25 DAS, indicating a strong relationship between these variables. PC2, on the other hand, had high loadings for weed density 25 DAS and weed dry weight at 25 DAS, suggesting their connection. Eigen values and the percentage of variance explained by each principal component were computed (**Table 5**). PC1 emerged as the dominant component, explaining 81.65% of the total variance, followed by PC2 with 16.46%. This suggests that the majority of the variance in the dataset is captured by these two components. PC3 and subsequent components explained progressively smaller amounts of variance.

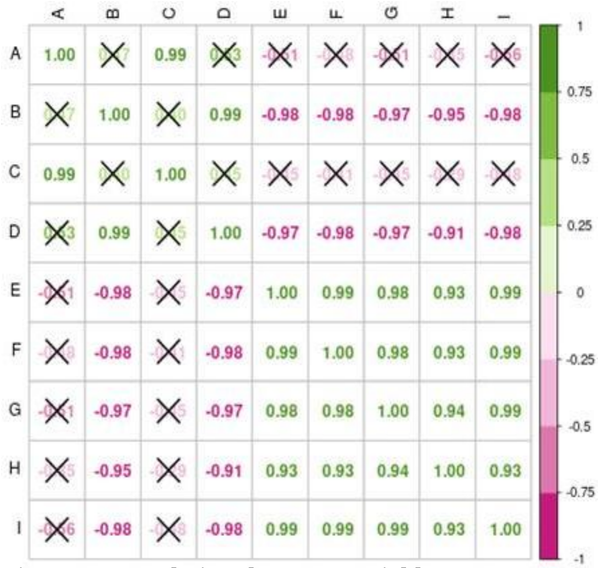

Figure 2. Correlations between variables

Where, A- Weed density at 25 DAS; B- Weed density at 50 DAS; C- Weed dry weight at 25 DAS; D- Weed dry weight at 50 DAS; E- No. of branches/plant; F- No. of pods/plant, G- shelling %; H- Seed index; I- Pod yield

Residual study on succeeding crop

Table 4 presents the residual effect of various herbicide treatments on the subsequent growth and yield attributes of wheat for two consecutive cropping seasons (2021-22 and 2022-23). The table provides valuable insights into the impact of these herbicides on plant population, plant height, no. of tillers per plant, grain yield, biological yield, and test weight. It's worth noting that there were no significant differences (NS) at the 5% level for

Table 3. Effect of integrated weed management on yield and economics of *Kharif* groundnut (pooled data of two years)

Treatment	Pod yield (t/ha)			Haulm yield (t/ha)	Gross returns (₹/ha)	Net returns ₹/ha)	B:C ratio
	2021-22	2022-23	Pooled				
Diclosulam 20 g/ha PE	1.55	1.31	1.43	2.80	95202	33348	1.54
Diclosulam 25 g/ha PE	1.85	1.70	1.77	3.37	117815	55621	1.89
Pendimethalin 1.0 kg/ha PE	1.83	1.68	1.76	3.35	116851	54852	1.88
Diclosulam 20 g/ha *fb* hand weeding at 30 and 60 DAS	1.93	1.75	1.84	3.51	122050	51196	1.72
Diclosulam 25 g/ha PE *fb* hand weeding at 30 and 60 DAS	2.02	1.80	1.91	3.67	127194	56000	1.79
Diclosulam 20 g/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS	1.68	1.69	1.68	3.21	112015	46161	1.70
Diclosulam 25 g/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS	1.98	1.89	1.94	3.71	128986	62527	1.94
Pendimethalin 1.0 kg/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 & 60 DAS	1.98	1.89	1.93	3.73	128815	62816	1.95
Hand weeding thrice at 25, 50 and 80 DAS/weed free check	2.10	1.96	2.03	3.76	134310	62060	1.86
Weedy check	1.00	0.91	0.96	1.69	62820	2820	1.05
LSD (p=0.05)	0.28	0.26	0.23	0.40	-	-	-

Table 4. Residual effect of herbicides on growth and yield attributes, yield and economics of succeeding wheat crop (pooled data of two years)

Treatment	Plant height (cm)	No. of tillers/ plant	Grain yield (t/ha) 2021-22	2022-23	Pooled	Biological yield (t/ha)	Test weight (%)
Diclosulam 20 g/ha PE	82.1	7.0	4.08	3.25	3.67	8.26	46.4
Diclosulam 25 g/ha PE	81.6	6.6	4.14	3.47	3.80	8.73	46.3
Pendimethalin 1.0 kg/ha PE	82.3	7.0	4.10	3.48	3.79	8.96	46.0
Diclosulam 20 g/ha *fb* hand weeding at 30 and 60 DAS	81.5	6.8	4.20	3.24	3.72	8.65	46.7
Diclosulam 25 g/ha PE *fb* hand weeding at 30 and 60 DAS	82.4	7.1	3.92	3.37	3.64	8.78	46.9
Diclosulam 20 g/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS	80.4	7.0	4.23	3.43	3.83	9.00	46.0
Diclosulam 25 g/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS	79.1	6.7	3.98	3.34	3.66	8.74	45.7
Pendimethalin 1.0 kg/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 & 60 DAS	81.8	6.5	4.05	3.34	3.69	8.51	46.5
Hand weeding thrice at 25, 50 and 80 DAS/weed free check	83.4	7.0	4.20	3.47	3.84	8.94	46.3
Diclosulam 20 g/ha PE	81.2	6.8	4.16	3.50	3.83	8.99	46.5
LSD (p=0.05)	NS	NS	NS	NS	NS	NS	NS

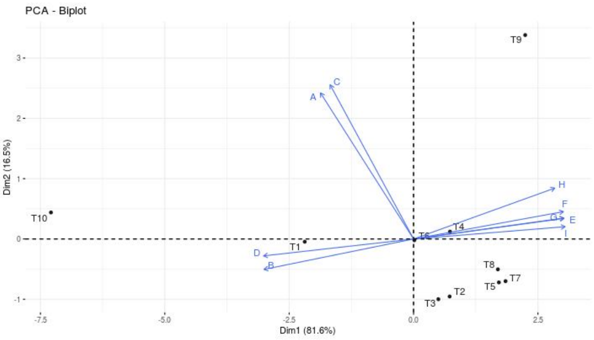

Figure 3. Principal component analysis of parameters.

Where, A- Weed density at 25 DAS; B- Weed density at 50 DAS; C- Weed dry weight at 25 DAS; D- Weed dry weight at 50 DAS; E- No. of branches/plant; F- No. of pods/plant, G- shelling %; H- Seed index; I- Pod yield

Table 5. Eigen values of principal component analysis

Principal component analysis	Eigen value	% of variance
PC1	7.348	81.648
PC2	1.481	16.461
PC3	0.091	1.007
PC4	0.041	0.459
PC5	0.016	0.18
PC6	0.014	0.155
PC7	0.005	0.057
PC8	0.003	0.033
PC9	0	0

various comparisons, as indicated by the critical difference (CD) values. Honnali and Satihal (2022) observed that diclosulam was applied on groundnut crop in the previous season at recommended (26 g/ha) and double the recommended dose (52 g/ha) and results were no adverse effect of diclosulam treatment 26 g/ha on sunflower as there was no injury on sunflower crop.

Effective weed control and higher groundnut pod yield were possible with pre-emergence application of diclosulam 25 g/ha PE *fb* quizalofop-ethyl 50 g/ha PoE at 30 and 60 DAS which could be an alternative to present recommendation of pendimethalin 1.0 kg/ha PE *fb* quizalofop-ethyl 50 g/ha POE at 30 and 60 DAS.

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