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Weed Management through Pre and Post-emergence Herbicides in Groundnut

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ABSTRACT

A field experiment was conducted at Agronomy Instructional Farm, Department of Agronomy, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Banaskantha (North Gujarat Agro-climatic Zone of Gujarat) during June–October, 2021 to assess the effect of pre- and post-emergence herbicides on weed control in groundnut crop using Randomized Block Design with ten treatments and four replications. Among different weed management practices, two hand weeding at 20 and 40 DAS recorded significantly higher number of pods per plant, resulted in significantly higher pod yield and haulm yield (23.70, 1980 kg ha^{-1} and 3082 kg ha^{-1}, respectively) which was found at par with interculturing and hand weeding at 15 and 30 DAS (22.90, 1892 kg ha^{-1} and 2950 kg ha^{-1}, respectively), post-emergence application of sodium acifluorfen 16.5+clodinafop-propargyl 8 EC @ 165+80 g ha^{-1} (22.53, 1835 kg ha^{-1} and 2864 kg ha^{-1}, respectively) and imazethapyr 35 WG+imazamox 35 WG @ 70 g ha^{-1} (21.93, 1800 kg ha^{-1} and 2811 kg ha^{-1}, respectively) due to better weed control of weeds as indicated by significantly lower density of sedges, grasses, broad leaf weeds and total weeds as evidenced by correlation and regression analysis between total weed density at 60 DAS, at harvest with the pod yield. Whereas, significantly lower number of pods per plant, pod yield and haulm yield at harvest were observed under unweeded check (10.30, 846 kg ha^{-1} and 1333 kg ha^{-1}, respectively) due to significantly higher density of sedges, grasses, broad leaf weeds and total weeds observed in unweeded check.

KEYWORDS: Correlation, groundnut, herbicides, nodules, regression, weed density, yield

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1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is one of the most important oilseed, food, fodder and cash crop in the world. It belongs to family Leguminosae and sub family Papilionaceae and popularly called as poor man's almond. These seeds can be directly consumed as a foodstuff, is a rich source of oil, protein and carbohydrates and other nutrition like tocopherol, niacin and folic acid; mineral components like Cu, Mn, K, Ca and P; dietary fibres, flavonoids, phytosterols like resveratrol, beta-sitosterol; and phenolic acids (Radhakrishnan et al., 2022). Globally, groundnut is cultivated on an area of 29.81 m ha with a production of 49.54 m t with an average productivity 16.62 q ha^{-1}. India ranks first in area and second in production after China. In 2022–23, the groundnut was sown on 4.96 m ha area and produced 10.30 m t of groundnut with a productivity of 2075 kg ha^{-1} (Anonymous, 2024). In Gujarat, groundnut is cultivated during *kharif* as well as summer seasons. The groundnut cultivation in Gujarat is largely confined to Junagadh, Jamnagar, Rajkot, Amreli, Saurashtra, Banaskantha and Bhavnagar districts. The Saurashtra region of Gujarat is considered as 'Bowl of groundnut' (Dinesh et al., 2010).

Among various biotic and abiotic factors, weed infestation (Adhikary and Patra, 2024) is the major biotic factor responsible for low productivity of groundnut. Though groundnut is a hardy crop still it is highly susceptible to weed preponderance due to small canopy and slow initial growth. 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). Weeds compete with crop plants for nutrients and remove more than 50% of applied nutrients under unweeded conditions resulting in significant yield reduction in groundnut (Naveen Kumar et al., 2019). Hence, managing weed population below the economic threshold level is the basic need to optimize the productivity in any cropping systems (Hatti et al., 2018). In groundnut, weeds compete with crop plants for nutrients and remove a significant quantity of applied nutrients resulting in significant yield reduction. In India, yield losses in groundnut due to weeds ranged from 24–70% (Jhala et al., 2005), however it depends on type of weed flora associated with groundnut. As groundnut is grown mainly in the rainy season when the conditions are more favorable for weed growth, that encourage repeated flushes of grasses and broad leaved weeds during the entire season for competition with the crop, more specifically during early stages of crop growth. The critical period for crop-weed competition was reported to be up to 45 days after sowing and yield losses up to 70% were recorded in groundnut due to weed infestation (Prasad et al., 2002). Thus, weed control is the foremost critical production factor in groundnut (Jat et al., 2011). Generally, weeds are controlled through hand weeding in groundnut, but it is expensive, laborious and sometimes continuous rains will interfere with timely weed control and often damage the economic produce (Ram and Singh, 2011). Maintenance of weed free environment during critical period is most important for enhancing productivity of groundnut, besides mechanical interculturing should be avoided at 45–50 days after sowing when pegging is initiated (Sharma et al., 2015). However, to manage these weeds the availability of labours at the right time and at nominal cost is the biggest challenge being faced by the farmers. Under such circumstances, chemical control of weeds may be the viable and cost effective alternative option for managing weeds (Ravi et al., 2023; Mehriya et al., 2024). Effective herbicide at appropriate rate may prove as an effective weed control strategy and replace conventional methods of weed control. In recent years, farmers are showing increased interest for use of herbicides to control weeds with the urge of reducing cost of cultivation, owing to shortage and high cost of labour (Savu et al., 2005). Considering these facts and views, an experiment was conducted to identify effective weed control approach in groundnut.

2. MATERIALS AND METHODS

A field experiment was conducted during June–October, 2021 at Agronomy Instructional Farm, Department of Agronomy, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Banaskantha (385506) (North Gujarat Agro-climatic region (AES IV) of Gujarat) at a 24° 19' North latitude and 72° 19' East longitude with an elevation of 154.52 meters above the mean sea level. The experiment was laid out in Randomized Block Design with ten treatments and four replications. The experimental field was ploughed by tractor drawn cultivator and was followed by harrowing and planking to obtain fine seedbed. The groundnut cultivar "TG 37" was sown manually at a spacing of 45×10 cm^2 at a depth of 4–5 cm on 1st July, 2021 with a seed rate of 120 kg ha^{-1}. The gross plot size and net plot size of the experiment were 5.0×4.5 m^2 and 4.0×2.7 m^2, respectively. The crop was fertilized with application of well decomposed FYM @ 5 t ha^{-1} at ten days before sowing and 12.5:25:20 kg NP_2O_5S ha^{-1} at sowing. The sources of fertilizers used were DAP, urea and bentonite Sulphur which were commonly applied to soil for all treatments just before sowing of seeds in the furrow. The groundnut seeds were treated with chlorpyriphos 20 EC @ 25 ml kg^{-1} seed. The first irrigation was given immediately after sowing and next irrigation was given eight days after sowing for ensuring proper germination and establishment of the seed. Remaining irrigations were given as per requirement of crop. Chlorphyriphos was applied @ 1.0 l ha^{-1} at 65 DAS by mixing it with fine sand to control the termite insects.

The weather data indicated that mean maximum temperature ranged between 29.0 to 39.1°C, while mean minimum temperature ranged between 18.0 to 26.8°C during the period of experimentation (July–October, 2021). The mean relative humidity recorded at morning and evening ranged from 66 to 88 and 59 to 90%, respectively. During the experimental period *i.e.*, *kharif* season, the total rainfall received was 429.5 mm. The bright sunshine hours and evaporation ranged between 0.0 to 9.9 hours' day^{-1} and 3.5 to 7.9 mm day^{-1}, respectively during crop period. All over climatological data indicated that the weather conditions were observed normal and favourable for the satisfactory growth and development of the groundnut crop during *kharif* season of 2021. The experimental field had an even topography with a gentle slope having good drainage. The soil of experimental field was loamy sand in texture with slightly alkaline in reaction, electrical conductivity within safe limit. The soil was low in organic carbon and available nitrogen, medium in available P_2O_5 and available K_2O and deficient in available S. The crop was manually harvested on 15th October, 2021 at physiological maturity. Randomly selected previously tagged five plants from each net plot were harvested separately for recording different biometric observations and later on these five plant yields were added to the seed yield of respective net plots. In interculturing treatment, interculturing was done by using manually operated cycle weeder. The spaying of different herbicides was done by using knapsack sprayer with flat fan nozzle having 15 litre capacity. All the pre and post-emergence herbicides were applied at one DAS and 30 DAS respectively with a spray volume of 500 l ha^{-1}. The required quantity of trade formulation of each herbicide for gross plots was calculated using the standard formula.

On the basis of visual observations, the occurrence of weed species was recorded. The species wise number of weeds per 0.25 m^2 from each plot was recorded from two spots at 30, 60 DAS and at harvest by using 50×50 cm^2 quadrate at random locations and was averaged over two spots. Further, the data was multiplied with four to convert the data into number m^{-2}. Since the weed count data does not follow normal distribution, the weed count data were analyzed after subjecting to $\sqrt{x+1}$ transformation as suggested by Gomez and Gomez (1984). All the growth and yield observation of groundnut were measured using standard procedures. The statistical analysis of the data collected for different parameters were carried out following the standard procedures[17].

3. RESULTS AND DISCUSSION

3.1. Effect on weed flora and weed density

3.1.1. Weed flora

The different species of weeds in groundnut crop at different crop growth stages (30, 60 DAS and harvest) were *Cyperus rotundus* L. among sedges, *Cynodon dactylon* L., *Digitaria marginata* L., *Digitaria sanguinalis* L. and *Dactyloctenium aegyptium* L. among grasses and *Portulaca oleracea* L., *Boerhavia erecta* L., *Tribulus terrestris* L., *Leucas aspera*, *Digera arvensis* L., *Commelina benghalensis* L. and *Amaranthus viridis* among broad leaf weeds. Among, sedges *Cyperus rotundus* L., among grasses *Cynodon dactylon* L. and among broad leaf weeds *Digera arvensis* L. were dominant at all stages (30, 60 DAS and harvest). Overall, the field was dominated with broad leaf weeds which were followed by grasses and sedges. Similar results were also obtained by Mudalagiriyappa et al. (2021).

3.1.2. Weed density

Density of weed was significantly influenced by different weed management practices in groundnut at 30, 60 DAS and at harvest (Table 1 to 3). Among different weed management practices, two hand weedings at 20 and 40 DAS recorded significantly lower density of sedges, grasses, broad leaf and total weeds at 30 DAS (5.88, 13.13, 8.75 and 27.75 m^{-2}, respectively) which was found on par with interculturing and hand weeding at 15 and 30 DAS, pre-emergence application of sulfentrazone 28+clomazone 30 WP @ 350+375 g ha^{-1} and diclosulam 84 WDG @ 22 g ha^{-1}. However, pre-emergence application of pendimethalin 38.7 CS @ 1000 g ha^{-1} had also recorded significantly lower weed density of grasses and found at par with two hand weedings at 20 and 40 DAS. Whereas, post-emergence herbicides *viz.*, sodium acifluorfen 16.5+clodinafop-propargyl 8 EC @ 165+80 g ha^{-1}, imazethapyr 10 SL @ 100 g ha^{-1}, fluthiacet-methyl 10.3 EC @ 13.6 g ha^{-1}, imazethapyr 35 WG+imazamox 35 WG @ 70 g ha^{-1} and unweeded check had recorded significantly higher density of sedges, grasses, broad leaf and total weeds (19.00, 44.63, 54.50 and 118.13 m^{-2}, respectively under unweeded check). Lower density of weeds in two hand weedings at 20 and 40 DAS and interculturing and hand weeding at 15 and 30 DAS treatment was due to effective uprooting and removal of weeds through physical and mechanical methods which ultimately resulted in lower sedges, grasses, broad leaf and total weeds. These findings were also supported by some researchers (El-Deek et al., 2011, Abouziena et al., 2013, Ravi et al., 2023, Adhikary and Patra, 2024 and Chitale et al., 2024) who implied that two hand hoeing were effective

Table 1: Category wise weed density at 30 DAS in groundnut as influenced by weed management practices

Treatments	Weed density (No. m^{-2})			
	Sedges	Grasses	Broad leaf weeds	Total
T_1: Pendimethalin 38.7 CS @ 1000 g ha^{-1} (PE)	3.71^{b} (12.88)	4.17^{b} (16.63)	5.31^{b} (27.38)	7.58^{b} (56.88)
T_2: Diclosulam 84 WDG @ 22 g ha^{-1} (PE)	3.15^{bc} (9.00)	3.97^{b} (15.25)	3.58^{c} (12.00)	6.09^{c} (36.25)
T_3: Sulfentrazone 28+clomazone 30 WP @ 350+375 g ha^{-1} (PE)	2.92^{c} (7.63)	4.10^{b} (16.13)	3.44^{c} (11.13)	5.98^{c} (34.88)
T_4: Sodium acifluorfen 16.5+clodinafop-propargyl 8 EC @ 165+80 g ha^{-1} (PoE)	4.59^{a} (20.13)	6.52^{a} (41.63)	7.23^{a} (51.63)	10.68^{a} (113.38)
T_5: Imazethapyr 10 SL @ 100 g ha^{-1} (PoE)	4.51^{a} (19.50)	6.64^{a} (43.38)	7.69^{a} (59.06)	11.07^{a} (121.94)
T_6: Fluthiacet-methyl 10.3 EC @ 13.6 g ha^{-1} (PoE)	4.42^{a} (19.00)	7.07^{a} (49.38)	7.27^{a} (52.50)	11.01^{a} (120.88)
T_7: Imazethapyr 35 WG+imazamox 35 WG @ 70 g ha^{-1} (PoE)	4.44^{a} (18.88)	6.27^{a} (38.50)	7.49^{a} (55.38)	10.65^{a} (112.75)
T_8: Interculturing and hand weeding at 15 and 30 DAS	2.65^{c} (6.13)	3.87^{b} (14.50)	3.15^{c} (9.38)	5.47^{c} (30.00)
T_9: Two hand weedings at 20 and 40 DAS	2.60^{c} (5.88)	3.74^{b} (13.13)	3.09^{c} (8.75)	5.35^{c} (27.75)
T_{10}: Unweeded check		4.46^{a} (19.00)	6.68^{a} (44.63)	7.44^{a} (54.50)
SEm±	0.23	0.34	0.29	0.33
CD (p=0.05)	0.68	1.00	0.83	0.97

Figures in parentheses are original values and figures outside the parentheses are √x+1 transformed values; Treatment means with the letter/s in common are not significantly different by DNMRT at 5% level of significance

Table 2: Category wise weed density at 60 DAS in groundnut as influenced by weed management practices

Treatments	Weed density (No. m^{-2})			
	Sedges	Grasses	Broad leaf weeds	Total
T_1: Pendimethalin 38.7 CS @ 1000 g ha^{-1} (PE)	3.83^{c} (13.75)	5.59^{c} (30.50)	5.72^{c} (32.00)	8.76^{c} (76.25)
T_2: Diclosulam 84 WDG @ 22 g ha^{-1} (PE)	3.82^{c} (13.63)	5.57^{c} (30.38)	5.56^{c} (30.25)	8.64^{c} (74.25)
T_3: Sulfentrazone 28+clomazone 30 WP @ 350+375 g ha^{-1} (PE)	3.79^{c} (13.50)	5.50^{c} (29.50)	5.53^{c} (29.75)	8.56^{c} (72.75)
T_4: Sodium acifluorfen 16.5+clodinafop-propargyl 8 EC @ 165+80 g ha^{-1} (PoE)	2.70^{e} (6.38)	4.04^{e} (15.63)	3.99^{e} (15.50)	6.13^{e} (37.50)
T_5: Imazethapyr 10 SL @ 100 g ha^{-1} (PoE)	3.45^{cd} (11.00)	5.01^{cd} (24.25)	5.07^{cd} (25.00)	7.82^{cd} (60.25)
T_6: Fluthiacet-methyl 10.3 EC @ 13.6 g ha^{-1} (PoE)	4.60^{b} (20.25)	6.63^{b} (43.50)	7.64^{b} (57.50)	11.04^{b} (121.25)
T_7: Imazethapyr 35 WG+imazamox 35 WG @ 70 g ha^{-1} (PoE)	3.04^{de} (8.50)	4.50^{de} (19.63)	4.30^{de} (17.75)	6.83^{de} (45.88)
T_8: Interculturing and hand weeding at 15 and 30 DAS	2.70^{e} (6.50)	4.00^{e} (15.25)	3.87^{e} (14.50)	6.07^{e} (36.25)
T_9: Two hand weedings at 20 and 40 DAS	2.54^{e} (5.88)	3.93^{e} (14.63)	3.68^{e} (12.88)	5.85^{e} (33.38)
T_{10}: Unweeded check	6.76^{a} (44.88)	8.03^{a} (64.00)	9.33^{a} (86.33)	14.01^{a} (195.20)
SEm±	0.19	0.31	0.33	0.35
CD (p=0.05)	0.55	0.90	0.94	1.02

Figures in parentheses are original values and figures outside the parentheses are √x+1 transformed values; Treatment means with the letter/s in common are not significantly different by DNMRT at 5% level of significance

Table 3: Category wise weed density at harvest in groundnut as influenced by weed management practices

Treatments	Weed density (No. m^{-2})			
	Sedges	Grasses	Broad leaf weeds	Total
T_1: Pendimethalin 38.7 CS @ 1000 g ha^{-1} (PE)	3.43^{c} (10.88)	4.92^{c} (23.63)	5.07^{c} (25.25)	7.73^{c} (59.75)
T_2: Diclosulam 84 WDG @ 22 g ha^{-1} (PE)	3.36^{c} (10.38)	4.85^{c} (22.63)	4.90^{c} (23.62)	7.56^{c} (56.63)
T_3: Sulfentrazone 28+clomazone 30 WP @ 350+375 g ha^{-1} (PE)	3.31^{c} (10.00)	4.78^{c} (22.14)	4.83^{c} (22.50)	7.44^{c} (54.64)
T_4: Sodium acifluorfen 16.5+clodinafop-propargyl 8 EC @ 165+80 g ha^{-1} (PoE)	2.40^{e} (4.88)	3.46^{e} (11.25)	3.39^{e} (10.88)	5.22^{e} (27.00)
T_5: Imazethapyr 10 SL @ 100 g ha^{-1} (PoE)	3.09^{cd} (8.61)	4.34^{cd} (18.00)	4.40^{cd} (18.63)	6.80^{cd} (45.24)
T_6: Fluthiacet-methyl 10.3 EC @ 13.6 g ha^{-1} (PoE)	4.16^{b} (16.38)	5.83^{b} (33.13)	6.64^{b} (43.13)	9.67^{b} (92.63)
T_7: Imazethapyr 35 WG+imazamox 35 WG @ 70 g ha^{-1} (PoE)	2.65^{de} (6.25)	3.87^{de} (14.12)	3.78^{de} (13.37)	5.88^{de} (33.74)
T_8: Interculturing and hand weeding at 15 and 30 DAS	2.36^{e} (4.75)	3.38^{e} (10.50)	3.32^{e} (10.38)	5.15^{e} (25.63)
T_9: Two hand weedings at 20 and 40 DAS	2.23^{e} (4.25)	3.32^{e} (10.38)	3.18^{e} (9.38)	4.97^{e} (24.00)
T_{10}: Unweeded check	5.92^{a} (34.25)	7.13^{a} (50.38)	8.39^{a} (69.89)	12.47^{a} (154.51)
SEm±	0.17	0.27	0.32	0.33
CD (p=0.05)	0.50	0.79	0.93	0.96

Figures in parentheses are original values and figures outside the parentheses are √x+1 transformed values; Treatment means with the letter/s in common are not significantly different by DNMRT at 5% level of significance

in lowering the dry weight of broad and narrow leaved weeds in peanut. The lower density of sedges, grasses, broad leaf weeds in pre-emergence herbicidal treatments *i. e.,* sulfentrazone 28+clomazone 30 WP @ 350+375 g ha^{-1} and diclosulam 84 WDG @ 22 g ha^{-1} was a reflection of their broad spectrum activity on sedges, grasses, broad leaf weeds which inhibited the germination of weeds itself in the soil which ultimately reduced total weed density at 30 DAS. The sulfentrazone+clomazone pre-mix herbicide mixture inhibits the protoporphyrinogen oxidase enzyme in sensitive weeds thereby affects membranes disruption and inhibits photosynthesis and leads to killing of broad leaf weeds, sedges and grasses. Whereas, diclosulam suppress the aceto lactate synthase (ALS) enzyme in the targeted weed plants which ultimately stops amino acids synthesis in the targeted weeds. Hence, affects protein synthesis and cell division, ultimately kills broad leaf weeds, sedges and grasses. Thus, due to suppression of respective enzymes by above herbicides in the sensitive weed plants, the effective weed control was achieved in the initial stages. The maximum reduction of the density of weeds in rice crop with application of sulfentrazone+clomazone herbicides at Matagalpa (Nicaragua) was witnessed by lower weed biomass as compared to the absolute control treatment (Laguna-Dávila and Alemán, 2016). The pre-emergence application of diclosulam provided at least 95% WCE for *Amaranthus viridis*, *Parthenium hysterophorus*, *Digera arvensis*, *Euphorbia* sp. and *Celosia* sp. in peanut crop (Meena et al., 2021). While, significantly higher density of sedges, grasses, broad leaf and total weeds under unweeded check treatment was clearly due to no measures taken to curtail the weed growth in the entire crop growth period. Thus, it had lead to uncontrolled and accelerated increase in weed density. It was witnessed that unweeded check treatment in greengram had recorded significantly higher density of weeds and weed dry weight with poorer weed control efficiency (Kumar et al., 2020).

At 60 DAS, two hand weedings at 20 and 40 DAS had significantly lower density of sedges, grasses broad leaf and total weeds and found at par with interculturing and hand weeding at 15 and 30 DAS, post-emergence application of sodium acifluorfen 16.5+clodinafop-propargyl 8 EC @ 165+80 g ha^{-1} and imazethapyr 35 WG+imazamox 35 WG @ 70 g ha^{-1}. However, significantly higher density of sedges, grasses, broad leaf and total weeds were observed under unweeded check. As already discussed above, the density of weeds recorded with lower magnitudes in two hand weedings at 20 and 40 DAS and interculturing and hand weeding at 15 and 30 DAS treatments are primarily because of uprooting and removal of weeds by physical and mechanical efforts which drastically made reduction in density of category wise weeds like sedges, grasses, broad leaf and total weeds (Mehriya et al., 2024). Moreover, some researchers found that significantly higher WCE (93.65%), lower weed dry weight (0.62 g m^{-2}) and lower WI (0%) were witnessed in hand weeding twice at 20 and 40 DAS in groundnut as compared to weedy check (Laguna-Dávila and Alemán, 2016). Similar outcomes were also expressed by the earlier researchers (Billore, 2017 and Sharma et al., 2015). The lower density of sedges, grasses and broad leaf weeds under PoE application of sodium acifluorfen 16.5+clodinafop-propargyl 8 EC @ 165+80 g ha^{-1} and imazethapyr 35 WG+imazamox 35 WG @ 70 g ha^{-1} treatments was attributed to their chemical nature and weed suppression ability. The ready mix combination of sodium acifluorfen and clodinafop-propargyl was responsible for combined inhibitory action through inhibition of protoporphyrinogen oxidase enzyme, thereby causing membranes disruption, photosynthesis suppression and acetyl CoA carboxylase (ACC-ase) enzyme that was involved in fatty acid synthesis in the selected target weeds. Thus, the combination had effectively controlled the category wise and lead to total weeds at 60 DAS. The application of ready–mix combination of imazethapyr 35 WG + imazamox 35 WG @ 70 g ha^{-1} had also resulted in suppression of the broad leaf weeds, grasses and sedges due to the inhibition of aceto lactate synthase (ALS) enzyme which was involved in synthesis of amino acids, that ultimately hampers the protein synthesis in the targeted weeds. The similar results were also noticed by few earlier researchers (Verma and Choudhary, 2020). While, significantly higher density of different category wise and total weeds under unweeded check treatment was because of absence of any weed control activity, hence had magnified the density of all the weeds (Rawat et al., 2017). It was evident from the Table 3 that, the same trend in the density of category wise and total weeds at harvest was recorded as that of 60 DAS. The density of sedges, grasses and broad leaf and total weeds at harvest was due to the same reasons as discussed at 60 DAS. Whereas, highest weed density of sedges, grasses, broad leaf and total weeds were noticed under unweeded check was also due to uncontrolled weed growth in the plot due to no weed control actions (Das et al., 2024).

3.2. *Effect on growth and yield parameters*

3.2.1. *Plant population*

The yield of any crop was dependent on establishment of optimum plant population, which ultimately serve as potential factor for realising optimum productivity of any crop. The data pertaining to effect of various weed management practices on plant population per meter row length at harvest was given in Table 4. Among different weed management practices, all the treatments had not significantly varied in plant population per meter row length at 30 DAS and at harvest except T_3 *i. e.*, pre-emergence application sulfentrazone 28+clomazone 30 WP @ 350+375 g ha^{-1} which had recorded significantly lower plant population at harvest (4.50 $meter^{-1}$ row length) due to the phytotoxicity of the herbicide mixture noticed on groundnut crop viz., stunting and discoloration of plants and severe plant stand loss. These results are in line with earlier workers who reported that clomazone, trifluralin and sulfentrazone were the ones that most affected the emergence of sorghum seedlings and sufentrazone and clomazone caused more than 40% toxicity at seven days after emergence (Dryden and Krishnamurthy, 1997).

3.2.2. *Growth and yield parameters*

The data on effect of different weed management practices on growth and yield parameters of the groundnut was described in Table 4. Weed management practices had significantly varied the plant height of groundnut at harvest (Table 4). An exploration of data stipulated that, two hand weedings at 20 and 40 DAS recorded significantly higher plant height at harvest, number of branches per plant, number of pods $plant^{-1}$ resulting in significantly higher pod and haulm yield (49.33 cm, 9.60, 23.70, 1980 kg ha^{-1} and 3082 kg ha^{-1}, respectively) which was found statistically on par with interculturing and hand weeding at 15 and 30 DAS (46.32 cm, 9.40, 22.90, 1892 kg ha^{-1} and 2950 kg ha^{-1}, respectively), post-emergence application sodium acifluorfen 16.5+clodinafop-propargyl 8 EC @ 165+80 g ha^{-1} (45.67 cm, 9.10, 22.53, 1835 kg ha^{-1} and 2864 kg ha^{-1}, respectively) and imazethapyr 35 WG+imazamox 35 WG @ 70 g ha^{-1} (45.57 cm, 9.00, 21.93, 1800 kg ha^{-1} and 2811 kg ha^{-1}, respectively). However, the treatment unweeded check recorded significantly lower plant height at harvest, number of branches $plant^{-1}$, number of pods $plant^{-1}$ resulting in significantly lower pod and haulm yield (21.49 cm, 7.00, 10.30, 846 kg ha^{-1} and 1333 kg ha^{-1}, respectively).

Whereas, significantly higher number of nodules and fresh weight of nodules $plant^{-1}$ at 45 DAS were observed in two hand weedings at 20 and 40 DAS (96.46 and 200.69 mg) which was at par with interculturing and hand weeding at 15 and 30 DAS (92.65 and 192.64 mg) and unweeded check (90.79 and 188.71 mg). However, all the herbicidal treatments had recorded lower number and fresh weight of nodules at 45 DAS. Comparatively, application of post-emergence herbicides *viz.*, sodium acifluorfen 16% EC+clodinafop propargyl 8% EC, imazethapyr 10 SL, fluthiacet-methyl 10.3 EC and imazethapyr 35 WG+imazamox had recorded lower number, fresh and dry weight of nodules than pre-emergence herbicides. Significantly lower number, fresh and dry weight of nodules chiefly due to application of post-emergence herbicides at 30 DAS *i.e.*, just before flowering (at 45 DAS) which hampered the nodulation activity due to application of post-emergence herbicides. These results are in line with

Table 4: Effect of weed management practices on various growth and yield parameters at harvest in groundnut

Treatments	Plant population per meter row length	Plant height (cm)	No. of branches plant^{-1}	No. of nodules plant^{-1}	Fresh weight of nodules (mg plant^{-1})	No. of pods plant^{-1}	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index (%)
T_1	9.13	37.70	8.20	82.35	171.88	18.40	1525	2387	38.98
T_2	9.25	39.38	8.45	81.51	169.70	18.68	1560	2441	38.99
T_3	4.50	28.21	7.30	60.15	125.22	11.30	971	1522	38.96
T_4	9.25	45.67	9.10	76.00	158.32	22.53	1835	2864	39.06
T_5	9.13	40.81	8.70	78.98	156.30	19.58	1619	2532	39.00
T_6	9.25	31.11	7.35	65.90	136.92	14.28	1222	1913	39.07
T_7	9.13	45.57	9.00	75.18	156.11	21.93	1800	2811	39.05
T_8	9.38	46.32	9.40	92.65	192.64	22.90	1892	2950	39.08
T_9	9.63	49.33	9.60	96.46	200.69	23.70	1980	3082	39.11
T_{10}	9.13	21.49	7.00	90.79	188.71	10.30	846	1333	38.83
SEm±	0.31	1.69	0.29	2.42	5.55	0.96	70.12	114.18	0.16
CD (p=0.05)	0.89	4.92	0.83	7.02	16.10	2.80	203.45	331.31	NS

some previous workers who quoted that application of imazethapyr @ 150 g ha^{-1} in groundnut adversely affected the nitrogenase activity and resulted in significantly lower total nodules and active nodules up to 45 DAS (Sudharshana et al., 2013). Whereas, the pre-emergence application of herbicides *viz.*, pendimethalin 38.7 CS, diclosulam 84 WDG and sulfentrazone 28+clomazone 30 WP registered higher values of number of nodules, fresh weight and dry weight of nodules next to hand weeding at 20 and 40 DAS, interculturing and hand weeding at 15 and 30 DAS and unweeded check might be due to sufficient time gap available for the recovery from effects of these chemicals on soil and plants. Significantly higher number of nodules, fresh weight and dry weight of nodules recorded under hand weeding at 20 and 40 DAS which were principally due to loosening of soil particles and proper soil aeration through hand weeding, which might had increased the soil microflora and ultimately root nodulation activities. Interculturing and hand weeding at 15 and 30 DAS and unweeded check had also recorded on par results with hand weeding at 20 and 40 DAS due to no chemicals application.

Significantly higher pod yields recorded under two hand weeding at 20 and 40 DAS, interculturing and hand weeding at 15 and 30 DAS, sodium acifluorfen 16.5+clodinafop-propargyl 8 EC @ 165+80 g ha^{-1} and imazethapyr 35 WG+imazamox 35 WG @ 70 g ha^{-1} was directly attributed to significantly higher growth, yield parameters and haulm yield recorded under these treatments *viz.*, number of pods plant^{-1} and haulm yield (23.70 g plant^{-1} and 3082 kg ha^{-1}, respectively under hand weeding; 22.90 g plant^{-1} and 2950 kg ha^{-1}, respectively under interculturing and hand weeding; 22.53 g plant^{-1} and 2864 kg ha^{-1}, respectively under sodium acifluorfen 16.5+clodinafop-propargyl 8 EC; 21.93 g plant^{-1} and 2811 kg ha^{-1}, respectively under imazethapyr 35 WG+imazamox 35 WG) due to creation of favourable conditions with lower crop-weed competition as a resultant of effective suppression of weeds which was indicated by significantly lower weed density of sedges, grasses, broad leaf weeds and total weeds (Table 1 to 3) in these treatments. The relationship between yield parameters and yield was evident from significantly strong positive correlation coefficient between number of pods plant^{-1}, pod yield plant^{-1} and haulm yield (0.9988**, 0.9966** and 0.9999*, respectively) with the pod yield of groundnut (Table 5).

The regression equations also revealed that increase in number of pods plant^{-1} by one plant^{-1}, pod yield plant^{-1} by one g plant^{-1} and haulm yield by 1 kg ha^{-1} at harvest increased the pod yield of groundnut by 80.62, 210.25 and 0.65 kg ha^{-1}, respectively (Table 5). These results are in concurrence with many earlier workers who witnessed higher growth attributes, yield attributes and yield of groundnut under treatments of hand-weeding, inter-culturing, sodium acifluorfen+clodinafop-propargyl and imazethapyr+imazamox due to better weed control. These improved yield parameters and yield in above treatments was a resultant of better weed control which was indicated by perfect negative correlation between pod yield *versus* weed densities. The correlation analysis between weed data and pod yield stipulated that there was perfect negative correlation between weed density at 60 DAS, weed density at harvest and pod yield (-0.8459*, -0.8421*, respectively). In addition, regression equations explored that each one m^{-2} increase in weed density at 60 DAS and at harvest reduced the pod yield of groundnut by 6.66 and 8.24 kg

Table 5: Correlation and regression equations for various dependent and independent parameters of groundnut

Independent variable (x)	Dependent variable (y)	Correlation coefficient (r)	Regression equation y {Pod yield (kg ha^{-1})}	R^2
Total weed density at 60 DAS (No.m^{-2})	Pod yield (kg ha^{-1})	-0.8459*	y=2027.17-6.66x	0.7156
Total weed density at harvest (No. m^{-2})		-0.8421*	y=1998.36-8.24x	0.7092
No. of pods plant^{-1} (No. plant^{-1})		0.9988**	y=45.48+80.62x	0.9976
Pod yield plant^{-1} (g)		0.9966**	y=-110.59+210.25x	0.9933
Haulm yield (kg ha^{-1})		0.9999*	y=-14.39+0.65x	0.9999

**=Significant at (p=0.01), *=Significant at (p=0.05); The variable×refers to the independent parameters listed in the column, variable y refers to the dependent parameters listed in the column

ha^{-1}, respectively.

Thus, as the weeds were effectively controlled in two hand weedings at 20 and 40 DAS, interculturing + hand weeding at 15 and 30 DAS, post-emergence application of sodium acifluorfen 16.5+clodinafop-propargyl 8 EC @ 165+80 g ha^{-1} and imazethapyr 35 WG+imazamox 35 WG @ 70 g ha^{-1} due to their physical action/mode of action of herbicides as discussed earlier, these treatments have recorded significantly higher yield attributes, pod and haulm yield. Kalhapure et al., 2013 and Ram et al., 2011 also supported these findings. On the other hand, unweeded check recorded significantly lower number of pods per plants, filled pods per plant and pod yield per plant which ultimately reduced pod yield and haulm yields due to severe and magnificent growth of weeds as compared to all other weed control treatments as evident by earlier works (Verma and Choudhary, 2020, Ravi et al., 2023, Chitale et al., 2024 and Sahu et al., 2024).

4. CONCLUSION

Two hand weedings at 20 and 40 DAS or interculturing and hand weeding at 15 and 30 DAS or post-emergence application of sodium acifluorfen 16.5+clodinafop-propargyl 8 EC @ 165+80 g ha^{-1} or imazethapyr 35 WG+imazamox 35 WG @ 70 g ha^{-1} depending on the availability of labours or herbicides were found effective for controlling weeds, higher pod yield, haulm yield and net returns as compared to unweeded check in *kharif* groundnut.

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