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Effect of different weed management practices on weed control, yield and profitability in groundnut (*Arachis hypogaea* L.) production system

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Abstract
A field experiment was conducted at Main Agricultural Research Station, Raichur during *kharif*, 2024 to study the effect of different weed management practices on growth, yield and economics of groundnut. The experiment was laid in RCBD with thirteen treatments and replicated thrice. The results revealed that application of diclosulam 84% WDG @ 31.25 g *a.i.* ha^{-1} as pre emergence *fb* propaquizafop 2.5% + imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} as post emergence at 18-20 DAS recorded higher weed control efficiency (89.53%) at 45 DAS, lower weed index (1.96%), significantly higher pod yield (2665 kg ha^{-1}), oil yield (945 kg ha^{-1}) and also resulted in higher gross returns (Rs. 1,50,737 ha^{-1}), net returns (Rs. 81,152 ha^{-1}) and BC ratio (2.17). However, application diclosulam 84% WDG @ 25.00 g *a.i.* ha^{-1} (PE) *fb* propaquizafop 2.5% + imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} (POE) at 18-20 DAS, application of pendimethalin 38.7% CS @ 677.25 g *a.i.* ha^{-1} (PE) *fb* propaquizafop 2.5% + imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} (POE) at 18-20 DAS and Intercultivation at 20 and 40 DAS *fb* one hand weeding at 30 DAS which were found on par with each other with respect to weed dynamics, yield and economics. Further, weedy check recorded higher total weed count, total dry weight of weeds, weed index and lower weed control efficiency, growth parameters, yield parameters, yield, quality parameters as well as net returns and BC ratio.

Keywords: Groundnut, weed management, Diclosulam, Propaquizafop + Imazethapyr

Introduction
India is one of the largest producers of oilseed crops in the world and has not achieved self-sufficiency in production. Among them, groundnut (*Arachis hypogaea* L.), commonly known as peanut, is considered the “poor man’s cashew nut” and “king of oilseed crops”. Belonging to the family Fabaceae, subfamily Papilionaceae, its name derives from the Greek words *Arachis* (legume) and *hypogaea* (Underground pod development). Groundnut originated in Brazil (South America) and was later introduced to India by Portuguese voyagers. Among the multitude of oilseed crops cultivated in India, groundnut stands as the second most extensively produced after mustard (Rabari, 2022) [14].

Groundnut is highly versatile, serving as food, fodder and a cash crop. Ranked as the third most significant source of vegetable protein and the fourth most vital source of edible oil globally, groundnut has an oil content of 45 per cent and contains 20 per cent high quality protein. They are rich in vitamin A, B and parts of the B_2 group, providing 349 calories per 100 grams (Bhondve *et al*., 2009) [3]. These nuts are also abundant in several essential minerals such as iron, manganese, zinc, boron, calcium and contain primary amounts of phosphorus, magnesium, sulphur and potassium. The stable and nutritious nature of groundnut is attributed to their proper ratio of oleic (40-45%) and linoleic acids (25-35%) (Mathur and Khan, 1997) [12]. Even the residual oil cake has high nutritional value, constituting 7 to 8 per cent N, 1.5 per cent P_2O_5 and 1.2 per cent K_2O and it is utilized as excellent animal feed due to its nitrogen, phosphorus and potassium content (Ibrahim *et al*., 2019) [7]. Groundnut haulms serve as nutritious livestock feed. Shells are used as fuel or industrial raw material. Being a legume, groundnut fixes 12 to 40 kg N ha^{-1} through symbiotic association with rhizobium, improving soil productivity and reducing

erosion risk.

Globally, groundnut occupies a substantial area of 29.81 million hectares, yielding a production of 49.54 million metric tons and displaying an average productivity of 16.62 quintals per hectare. India proudly stands among the top three groundnut-producing countries, holding the second position, trailing only China, which contributes 37 per cent of the world's groundnut production. In India, Gujarat, Rajasthan, Madhya Pradesh, Telangana, Tamil Nadu, Uttar Pradesh, Karnataka and Maharashtra accounts for 80 per cent of groundnut production and 84 per cent of its area. Notably, in Karnataka, major groundnut-growing districts include Chitradurga, Dharwad, Belgavi, Vijayapura, Raichur, Ballari and Bidar with area of 4.06 lakh hectares, production of 4.09 lakh tonnes and productivity of 1007 kg per hectare (Anon., 2025) [1].

About 85 per cent of Indian groundnut is grown in *kharif* under rainfed conditions, where yield is reduced by vagaries of monsoon and biotic stresses. Weeds are the most serious, as groundnut's slow initial growth, short stature and underground podding make it vulnerable. Yield losses of 13-18 per cent were estimated due to weeds in groundnut (Jakhar and Sharma, 2015) [8]. Weed management is an important agronomic aspect in crop production, as weed cause the highest percentage of damage to the crop, especially in dry regions where they compete with the crops for water, nutrients, CO_2 and light, ultimately reducing the crop yields. Traditional weed control such as hand weeding or intercultural operations are effective but costly, labour-intensive and difficult under continuous rains or labour scarcity. Mechanical weeders have a risk of crop damage, especially after peg initiation.

The chemical method of weed control is found to be cheap and effective than other traditional method of weed management. Hence, to reduce the risk and cost, chemical practices can be adopted along with the traditional practice of manual hand weeding. Thus, the crop take advantage over weeds by supressing their growth. This not only increases the yield but also reduces the cost of cultivation by decreasing the labour cost. Finally, the productivity per unit land can be increased which increases the national income and accelerates the development of the nation. Thus, the proposal of doubling the farmer's income can be made true in a sustainable manner through crop intensification approach. Use of herbicides must be chosen with respect to selectivity to the crop. Certain herbicides can be applied as pre-emergent which helps in checking the weed growth in early stages of crop growth. Further, weed population if any could easily be checked by some post-emergent herbicides or by following manual hand weeding and intercultivation.

At present, pendimethalin and oxyfluorfen are contemporary pre-emergent herbicides used in groundnut (Jat *et al*., 2011) [9], but are not very effective against broad-leaved weeds. However, new molecules are environmental friendly and more effective, which are being discovered and used as next-generation herbicides to address labour shortage, early weed control, prevent development of herbicide resistance in weed species and reduce weeding costs. Diclosulam is a novel selective pre-emergent herbicide belonging to class of Triazolopyrimidine sulphonamide, which is highly effective for the control of broad-leaved weeds in a number of field crops and forestry applications (Singh *et al*., 2009) [16]. It inhibits the enzyme Acetolactate synthase (ALS), thus stops the synthesis of branched chain amino acids and supress the weed growth. In order to test the efficacy of this alternate chemical, the present study on the use of diclosulam as pre-emergent herbicides in groundnut was planned. Moreover, in Karnataka state, testing efficacy of this new molecule in groundnut has not yet been popularized. Thus, a field experiment was formulated to evaluate the suitable dose of diclosulam herbicide to manage the weeds in groundnut for better results with low cost. Keeping this in view, an attempt was made to find out the efficiency of diclosulam as a pre-emergent herbicide on weeds, crop productivity and economics of *kharif* groundnut.

Materials and Methods

The experiment was conducted during *kharif* season of 2024 at Main Agricultural Research Station, University of Agricultural Sciences, Raichur, which is situated at a latitude of 16° 12′ N, longitude of 77° 20′ E and at an elevation of 389 metres above the mean sea level and it falls under North-Eastern Dry Zone of Karnataka (Zone-2). The soil sample of the experimental site was medium deep clay soil in texture. Regarding chemical properties, the soil pH was slightly alkaline (8.13) with an electrical conductivity of 0.53 dS m^{-1}. The soil was low in organic carbon content (0.46%), low in available nitrogen (232.15 kg ha^{-1}), medium in available phosphorus (23.33 kg ha^{-1}) and high in available potassium (378.80 kg ha^{-1}).

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications and thirteen treatments comprising of pre-emergent and post emergent herbicides along with cultural practices like hand weeding and intercultivation. The treatments are diclosulam 84% WDG @ 6.25 g *a.i.* ha^{-1} (PE) *fb* IC at 25 and 35 DAS (T_1), diclosulam 84% WDG @ 12.50 g *a.i.* ha^{-1} (PE) *fb* IC at 25 and 35 DAS (T_2), diclosulam 84% WDG @ 25.00 g *a.i.* ha^{-1} (PE) *fb* IC at 25 and 35 DAS (T_3), diclosulam 84% WDG @ 31.25 g *a.i.* ha^{-1} (PE) *fb* IC at 25 and 35 DAS (T_4), pendimethalin 38.7% CS @ 677.25 g *a.i.* ha^{-1} (PE) *fb* IC at 25 and 35 DAS (T_5), diclosulam 84% WDG @ 6.25 g *a.i.* ha^{-1} (PE) *fb* propaquizafop 2.5% + imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} (POE) at 18-20 DAS (T_6), diclosulam 84% WDG @ 12.50 g *a.i.* ha^{-1} (PE) *fb* propaquizafop 2.5% + imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} (POE) at 18-20 DAS (T_7), diclosulam 84% WDG @ 25.00 g *a.i.* ha^{-1} (PE) *fb* propaquizafop 2.5% + imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} (POE) at 18-20 DAS (T_8), diclosulam 84% WDG @ 31.25 g *a.i.* ha^{-1} (PE) *fb* propaquizafop 2.5% + imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} (POE) at 18-20 DAS (T_9), pendimethalin 38.7% CS @ 677.25 g *a.i.* ha^{-1} (PE) *fb* propaquizafop 2.5% + imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} (POE) at 18-20 DAS (T_{10}), IC at 20 and 40 DAS *fb* one hand weeding at 30 DAS (T_{11}), weed free check (T_{12}) and weedy check (T_{13}). The groundnut variety used was K.D.G.-128 which matures in 115-120 days and suitable for *kharif* season with a spacing of 30 cm x 10 cm.

Weed control efficiency (WCE) denotes the magnitude of reduction in weed biomass due to the weed management treatments. The weed control efficiency was calculated by using the formula given by Lal (1990) [11]. Weed control efficiency was calculated at 15, 30, 45, 60 days after herbicide application (DAHA) and at harvest.

$$WCE\ (\%) = \frac{W_c - W_t}{W_c} \times 100$$

Where,

W_c = Dry weight of weeds in weedy check (g m^{-2})

W_t = Dry weight of weeds in respective treatment plot (g m^{-2})

Pods from net plot area (including the pods from labelled plants)

were dried until constant weight was gained and expressed as pod yield in kilogram per hectare.

Weed index (WI) is the reduction in crop yield due to the presence of weeds in comparison with weed free check and expressed as percentage. In other words, weed index expresses the competition offered by weeds, measured by per cent reduction in yield owing to their presence in the field. Weed index was calculated by using the formula given by Gill and Kumar (1992) [5].

$$WI\ (\%) = \frac{X - Y}{X} \times 100$$

Where,

X = Pod yield (kg ha^{-1}) from the weed free plot or best treatment plot

Y = Pod yield (kg ha^{-1}) from the treatment for which weed index has to be calculated

Oil yield per hactare was worked out on the basis of seed oil content and kernel yield of groundnut.

$$\text{Oil yield (kg ha}^{-1}) = \frac{\text{Oil content in seed (\%)} \times \text{kernel yield (kg ha}^{-1})}{100}$$

The economics was worked out based on the prevailing market price for the existing year. The technique of fisher's method of analysis of variance as described by Gomez and Gomez (1984) [6] was carried out for the analysis and interpretation of data. The level of significance used in 'F' and 't' test was at 5 per cent.

Results and Discussion

Weed control efficiency (%)

At all stages, weed control efficiency was found to be significantly higher in weed free check (100%). Whereas, lower weed control efficiency was found in weedy check (0%). At 15 DAS, lower weed control efficiency was observed in the treatment Diclosulam 84% WDG @ 6.25 g *a.i.* ha^{-1} (PE) *fb* IC at 25 and 35 DAS and Diclosulam 84% WDG @ 6.25 g *a.i.* ha^{-1} (PE) *fb* Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} (POE) at 18-20 DAS (43.01 and 49.41%, respectively) due to higher total dry weight of weeds and application of herbicides in low concentration. At 30 DAS, higher weed control efficiency was observed in the treatment Diclosulam 84% WDG @ 31.25 g *a.i.* ha^{-1} (PE) *fb* IC at 25 and 35 DAS and Diclosulam 84% WDG @ 31.25 g *a.i.* ha^{-1} (PE) *fb* Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} (POE) at 18-20 DAS (95.87 and 92.55%, respectively) due to lower total dry weight of weeds and application of herbicides in higher concentration. At 45 DAS, significantly higher weed control efficiency was observed in IC at 20 and 40 DAS *fb* one hand weeding at 30 DAS (93.60%). Among the herbicide treatments, application of Diclosulam 84% WDG @ 31.25 g *a.i.* ha^{-1} (PE) *fb* Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} (POE) at 18-20 DAS had resulted in higher weed control efficiency (95.87%), which was followed by Diclosulam 84% WDG @ 25.00 g *a.i.* ha^{-1} (PE) *fb* Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} (POE) at 18-20 DAS (93.53%) and Pendimethalin 38.7% CS @ 677.25 g *a.i.* ha^{-1} (PE) *fb* Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} (POE) at 18-20 DAS (90.85%). At 60 DAS and at harvest, significantly higher weed control efficiency was observed in IC at 20 and 40 DAS *fb* one hand weeding at 30 DAS (89.43 and 84.68%, respectively). Among the herbicide treatments, application of Diclosulam 84% WDG @ 31.25 g *a.i.* ha^{-1} (PE) *fb* Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} (POE) at 18-20 DAS had resulted in higher weed control efficiency (86.36 and 84.45%, respectively), which was followed by Diclosulam 84% WDG @ 25.00 g *a.i.* ha^{-1} (PE) *fb* Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} (POE) at 18-20 DAS (83.69 and 80.42%, respectively) and Pendimethalin 38.7 CS @ 677.25 g *a.i.* ha^{-1} (PE) *fb* Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} (POE) at 18-20 DAS (83.25 and 80.57%, respectively).

The higher weed control efficiency in weed free check at all stages was due to complete elimination of weeds through frequent hand weeding operations in the treatment. The lower weed control efficiency was reported from weedy check due to elimination of all kinds of weed management measures which in turn led to significantly higher dry weight of weeds in the treatment. However, at 30 DAS, Diclosulam 84% WDG at 31.25 g *a.i.* ha^{-1} (PE) resulted in a considerably larger WCE. Propaquizafop + Imazethapyr was then applied post-emergently or by intercultivation (95.87% and 92.55%, respectively). The increased herbicide concentration, which successfully inhibited early weed emergence and growth, is responsible for the enhanced WCE at this point. Pre-emergent ALS inhibitor Diclosulam, decreased early weed emergence by interfering with amino acid synthesis. Extended weed control was achieved by the post-emergent combination of Imazethapyr, a systemic ALS inhibitor that works against broad-leaved weeds and sedges, and Propaquizafop, an ACCase inhibitor that targets grassy weeds. By focusing on several weed species at various phases of crop growth, these herbicides collectively considerably decreased the overall dry weight of weeds and promote higher weed control efficiency. This kind of result in weed control efficiency was also reported by Musa *et al.* (2022) [13]. Where they noticed that higher weed control efficiency was obtained with application of Diclosulam 84% WDG @ 25 g *a.i.* ha^{-1} as a pre-emergence *fb* Imazethapyr 10% SL @ 100 g *a.i.* ha^{-1} (POE) at 18-20 DAS (81.30%) at crop maturity, due to more effective control of all categories of weeds including predominant weeds.

Pod yield (kg ha^{-1})

Weed free check recorded significantly higher pod yield (2718 kg ha^{-1}) which was 33 per cent higher over weedy check. Among the herbicide treatments, significantly higher pod yield was recorded with pre-emergent application of Diclosulam 84% WDG @ 31.25 g *a.i.* ha^{-1} *fb* post-emergent application of Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS (2665 kg ha^{-1}) which was 30.5 per cent higher over weedy check and statistically on par with pre-emergent application of Diclosulam 84 % WDG @ 25.00 g *a.i.* ha^{-1} *fb* post-emergent application of Propaquizafop + Imazethapyr 3.75 % w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS (2601 kg ha^{-1}) which was 27 per cent higher over weedy check, pre-emergent application of Pendimethalin 38.7 % CS @ 677.25 g *a.i.* ha^{-1} *fb* post-emergent application of Propaquizafop + Imazethapyr 3.75 % w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS (2531 kg ha^{-1}) which was 24 per cent higher over weedy check and IC at 20 and 40 DAS *fb* one hand weeding at 30 DAS (2549 kg ha^{-1}) which was 25 per cent higher over weedy check. Weedy check recorded significantly lower pod yield (2041 kg ha^{-1}).

Since there was no weed competition, the crop was able to make full use of vital resources including nutrients, water, sunlight and space during its growth cycle, resulting in the maximum

groundnut pod production in the weed free check. Strong vegetative growth, increased photosynthetic efficiency, improved blooming and pegging, eventually increased pod formation and development were all results of uninterrupted resource availability. On the other hand, sedges, grasses and broad-leaved weeds fiercely competed with the weedy check plots, particularly at crucial phases like flowering and pod filling. Stunted growth, decreased peg penetration, poor pod filling and a notable decline in total pod production were the outcomes of this battle for nutrients and water. Treatment with Diclosulam at 31.25 g and 25 g *a.i.* ha^{-1} or Pendimethalin prior to an application of Propaquizafop + Imazethapyr post-emergently showed the maximum pod production. These treatments successfully reduced crop-weed competition at all crucial growth stages by offering broad spectrum, season long weed control. As a result, the crop was able to grow and develop reproductively to their full potential, producing the most pods possible. Similar results were also noticed in the earlier investigations of Kumar *et al*. (2020) [10].

Weed index (%)

The lower weed index was recorded in weed free check (0%), whereas higher weed index was observed in weedy check (24.91%). Among the herbicide treatments, pre-emergent application of Diclosulam 84% WDG @ 31.25 g *a.i.* ha^{-1} *fb* post-emergent Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS had recorded significantly lower weed index (1.96%) which was followed by pre-emergent application of Diclosulam 84 % WDG @ 25.00 g *a.i.* ha^{-1} *fb* post-emergent application of Propaquizafop + Imazethapyr 3.75 % w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS (4.30%), pre-emergent application of Pendimethalin 38.7 % CS @ 677.25 g *a.i.* ha^{-1} *fb* post-emergent application of Propaquizafop + Imazethapyr 3.75 % w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS (6.89%) and IC at 20 and 40 DAS *fb* one hand weeding at 30 DAS (6.22%).

Since there was no weed interference during the crop's growth period, the weed index which calculates the decrease in crop production brought on by weed competition was lowest in the weed free check. Groundnut plants had the best growth, resource use and pod development when there were no weeds present. This resulted in maximum production and thus, the least amount of yield loss, which gave the plants the lowest weed index. Among the treatments, the lowest weed index was recorded in plots where a pre-emergent application of Diclosulam at 31.25 g and 25 g *a.i.* ha^{-1} or Pendimethalin was combined with a post-emergent application of herbicide combination Propaquizafop + Imazethapyr. So, there was successfully reduced competition against groundnut during crucial periods of crop growth, this combined herbicide method offered broad spectrum control of weeds. As a result, groundnut plants were able to sustain high pod yield, which decreased the weed index. The result of the experiment is in consistent with the findings of Sharma *et al.* (2015) [15].

Oil yield (kg ha^{-1})

Among herbicide treatments significantly higher oil yield was obtained in pre-emergent application of Diclosulam 84% WDG @ 31.25 g *a.i.* ha^{-1} *fb* post-emergent Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS (945 kg ha^{-1}) which was statistically similar with pre-emergent application of Diclosulam 84 % WDG @ 25.00 g *a.i.* ha^{-1} *fb* post-emergent application of Propaquizafop + Imazethapyr 3.75 % w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS (908 kg ha^{-1}), pre-emergent application of Pendimethalin 38.7 % CS @ 677.25 g *a.i.* ha^{-1} *fb* post-emergent application of Propaquizafop + Imazethapyr 3.75 % w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS (878 kg ha^{-1}) and IC at 20 and 40 DAS *fb* one hand weeding at 30 DAS (898 kg ha^{-1}). Nevertheless, significantly lower oil yield was recorded in weedy check (459 kg ha^{-1}) and significantly higher oil yield was recorded in weed free check (978 kg ha^{-1}).

Oil yield of groundnut is a function of both kernel yield and oil content and is largely determined by the extent of crop weed competition. Due to improved crop growth and nutrient absorption in the absence of weed competition throughout the crop length, the groundnut oil yield in the weed free check was significantly greater. Conditions devoid of weeds encourage effective photosynthesis, improved pod development and seed filling, all of which lead to larger kernel yields, which in turn raise oil output. By competing with nutrients, light, water and space, the weedy check on the other hand, seriously impairs crop development. This results in poor pod formation and decreased seed output, which in turn drastically reduces the oil yield. Effective and long-lasting weed control can be achieved by applying relatively higher doses of Diclosulam (31.25 and 25 g *a.i.* ha^{-1}) and Pendimethalin before to the emergence, followed by post-emergent Propaquizafop + Imazethapyr. This promotes crop growth and kernel development and ultimate yields. This outcome corresponds to the research by Chinmayi *et al.* (2023) [4].

Economics

Cost of cultivation (Rs. ha^{-1})

Among the different treatments, the higher cost of cultivation in groundnut production system was recorded with weed free check followed by pre-emergent application of Diclosulam 84% WDG @ 31.25 g *a.i.* ha^{-1} *fb* post-emergent Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS and (Rs.75,451 and 69,585 ha^{-1}, respectively). Nevertheless, lower was cost of cultivation recorded in weedy check (Rs.62,951 ha^{-1}). Because of non-adoption of any of the weed management methods making it as the control treatment. This result is in corresponds with findings of Bhagyashree *et al.* (2018) [2].

Gross returns (Rs. ha^{-1})

In groundnut production system, the maximum gross returns was recorded in weed free check (Rs.1,53,788 ha^{-1}) which is followed by pre-emergent application of Diclosulam 84% WDG @ 31.25 g *a.i.* ha^{-1} *fb* post-emergent Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS and pre-emergent application of Diclosulam 84 % WDG @ 25.00 g *a.i.* ha^{-1} *fb* post-emergent application of Propaquizafop + Imazethapyr 3.75 % w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS (Rs.1,50,737 and 1,47,206 ha^{-1}, respectively). Minimum gross returns was recorded in weedy check (Rs.1,15,709 ha^{-1}).

Higher gross returns can be attributed to the enhanced productivity of both pod and haulm yield as a result of effective weed management practices.

Net returns (Rs. ha^{-1})

Significantly higher net returns in groundnut production system was recorded in the treatment pre-emergent application of Diclosulam 84% WDG @ 31.25 g *a.i.* ha^{-1} *fb* post-emergent Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS (Rs.81,152 ha^{-1}). Which is statistically at par with weed free check (Rs.78,338 ha^{-1}), pre-emergent application of Diclosulam 84 % WDG @ 25.00 g *a.i.* ha^{-1} *fb* post-emergent

application of Propaquizafop + Imazethapyr 3.75 % w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS (Rs.78,008 ha^{-1}) and IC at 20 and 40 DAS *fb* one hand weeding at 30 DAS (Rs.76,869 ha^{-1}). Nevertheless, significantly lower net returns was observed in the treatment pre-emergent application of Diclosulam 84% WDG @ 6.25 g *a.i.* ha^{-1} *fb* post-emergent Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS (Rs.52,462 ha^{-1}).

Lower net returns observed in weedy check might be due to lower gross returns which were dependent on the pod and haulm yield. Among the herbicide treatments, significantly higher net returns was observed with pre-emergent application of Diclosulam 84% WDG @ 31.25 g *a.i.* ha^{-1} *fb* post-emergent Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS and pre-emergent application of Diclosulam 84 % WDG @ 25.00 g *a.i.* ha^{-1} *fb* post-emergent application of Propaquizafop + Imazethapyr 3.75 % w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS. which might be due to higher pod and haulm yield recorded in the treatment along with lower cost of cultivation because of lower costs of herbicides than intercultivation. Which is laborious and time consuming besides being costly. This result on the net returns of the present study is in close proximity with the findings of Chinmayi *et al*. (2023) [4].

Benefit cost ratio (B:C)

Significantly higher benefit-cost ratio in groundnut production system was recorded in pre-emergent application of Diclosulam 84% WDG @ 31.25 g *a.i.* ha^{-1} *fb* post-emergent Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS (2.17). Which is statistically at par with weed free check (2.04), pre-emergent application of Diclosulam 84 % WDG @ 25.00 g *a.i.* ha^{-1} *fb* post-emergent application of Propaquizafop + Imazethapyr 3.75 % w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS (2.13), pre-emergent application of Pendimethalin 38.7% CS @ 677.25 g *a.i.* ha^{-1} *fb* post-emergent application of Propaquizafop + Imazethapyr 3.75 % w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS (2.08) and IC at 20 and 40 DAS *fb* one hand weeding at 30 DAS (2.14). Significantly lower benefit-cost ratio was observed in the treatment pre-emergent application of Diclosulam 84% WDG @ 6.25 g *a.i.* ha^{-1} *fb* post-emergent Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS (1.75).

This might be due to higher gross returns with the lower cost of cultivation, whilst the minimum benefit-cost ratio was observed in weedy check which was due to lower gross returns observed from the treatment. Such similar results were also reported by Musa *et al.* (2022) [13].

Table 1: Weed control efficiency (%) at different growth stages of groundnut as influenced by different weed management practices

Treatment	15 DAHA	30 DAHA	45 DAHA	60 DAHA	At harvest
T_1: Diclosulam 84% WDG @ 6.25 g *a.i.* ha^{-1} (PE) *fb* IC at 25 and 35 DAS	43.01	62.38	56.77	50.29	50.20
T_2: Diclosulam 84% WDG @ 12.50 g *a.i.* ha^{-1} (PE) *fb* IC at 25 and 35 DAS	54.45	70.85	62.81	57.25	56.72
T_3: Diclosulam 84% WDG @ 25.00 g *a.i.* ha^{-1} (PE) *fb* IC at 25 and 35 DAS	87.09	88.45	75.77	71.37	70.29
T_4: Diclosulam 84% WDG @ 31.25 g *a.i.* ha^{-1} (PE) *fb* IC at 25 and 35 DAS	95.39	92.55	77.86	75.79	73.46
T_5: Pendimethalin 38.7% CS @ 677.25 g *a.i.* ha^{-1} (PE) *fb* IC at 25 and 35 DAS	87.72	88.47	74.28	72.68	70.68
T_6: Diclosulam 84% WDG @ 6.25 g *a.i.* ha^{-1} (PE) *fb* Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} (POE) at 18-20 DAS	49.41	69.12	65.94	59.88	59.79
T_7: Diclosulam 84% WDG @ 12.50 g *a.i.* ha^{-1} (PE) *fb* Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} (POE) at 18-20 DAS	61.00	73.87	71.45	66.06	64.31
T_8: Diclosulam 84% WDG @ 25.00 g *a.i.* ha^{-1} (PE) *fb* Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} (POE) at 18-20 DAS	88.85	93.53	86.66	83.69	80.42
T_9: Diclosulam 84% WDG @ 31.25 g *a.i.* ha^{-1} (PE) *fb* Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1}(POE) at 18-20 DAS	93.33	95.87	89.53	86.36	84.45
T_{10}: Pendimethalin 38.7% CS @ 677.25 g *a.i.* ha^{-1} (PE) *fb* Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} (POE) at 18-20 DAS	83.28	90.85	85.34	83.25	80.57
T_{11}: IC at 20 and 40 DAS *fb* one hand weeding at 30 DAS	29.88	75.67	93.60	89.43	84.68
T_{12}: Weed free check	100.00	100.00	100.00	100.00	100.00
T_{13}: Weedy check	0.00	0.00	0.00	0.00	0.00

Note			
PE = Pre-emergent		POE = Post-emergent	
a.i. = Active ingredient	DAHA = Days after herbicide application	DAS = Days After Sowing	*fb* = Followed by
IC = Intercultivation	CS = Capsulated suspension	WDG = Water dispersible granules	ME = Micro emulsion

Table 2: Pod yield, weed index and oil yield of groundnut as influenced by different weed management practices

Treatment	Pod yield (kg ha^{-1})	Weed index (%)	Oil yield (kg ha^{-1})
T_1: Diclosulam 84% WDG @ 6.25 g *a.i.* ha^{-1} (PE) *fb* IC at 25 and 35 DAS	2093	22.99	497
T_2: Diclosulam 84% WDG @ 12.50 g *a.i.* ha^{-1} (PE) *fb* IC at 25 and 35 DAS	2156	20.68	559
T_3: Diclosulam 84% WDG @ 25.00 g *a.i.* ha^{-1} (PE) *fb* IC at 25 and 35 DAS	2275	16.30	669
T_4: Diclosulam 84% WDG @ 31.25 g *a.i.* ha^{-1} (PE) *fb* IC at 25 and 35 DAS	2359	13.21	705
T_5: Pendimethalin 38.7% CS @ 677.25 g *a.i.* ha^{-1} (PE) *fb* IC at 25 and 35 DAS	2214	18.54	639
T_6: Diclosulam 84% WDG @ 6.25 g *a.i.* ha^{-1} (PE) *fb* Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} (POE) at 18-20 DAS	2104	22.59	514
T_7: Diclosulam 84% WDG @ 12.50 g *a.i.* ha^{-1} (PE) *fb* Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} (POE) at 18-20 DAS	2199	19.09	586
T_8: Diclosulam 84% WDG @ 25.00 g *a.i.* ha^{-1} (PE) *fb* Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} (POE) at 18-20 DAS	2601	4.30	908
T_9: Diclosulam 84% WDG @ 31.25 g *a.i.* ha^{-1} (PE) *fb* Propaquizafop 2.5% + Imazethapyr	2665	1.96	945

3.75% w/w ME @ 125 g *a.i.* ha^{-1}(POE) at 18-20 DAS			
T_{10}: Pendimethalin 38.7% CS @ 677.25 g *a.i.* ha^{-1} (PE) *fb* Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} (POE) at 18-20 DAS	2531	6.89	878
T_{11}: IC at 20 and 40 DAS *fb* one hand weeding at 30 DAS	2549	6.22	898
T_{12}: Weed free check	2718	0.00	978
T_{13}: Weedy check	2041	24.91	459
S.Em. ±	77	-	48
L.S.D. at 5%	226	-	140

Note			
PE = Pre-emergent		POE = Post-emergent	
a.i. = Active ingredient	DAHA = Days after herbicide application	DAS = Days After Sowing	*fb* = Followed by
IC = Intercultivation	CS = Capsulated suspension	WDG = Water dispersible granules	ME = Micro emulsion

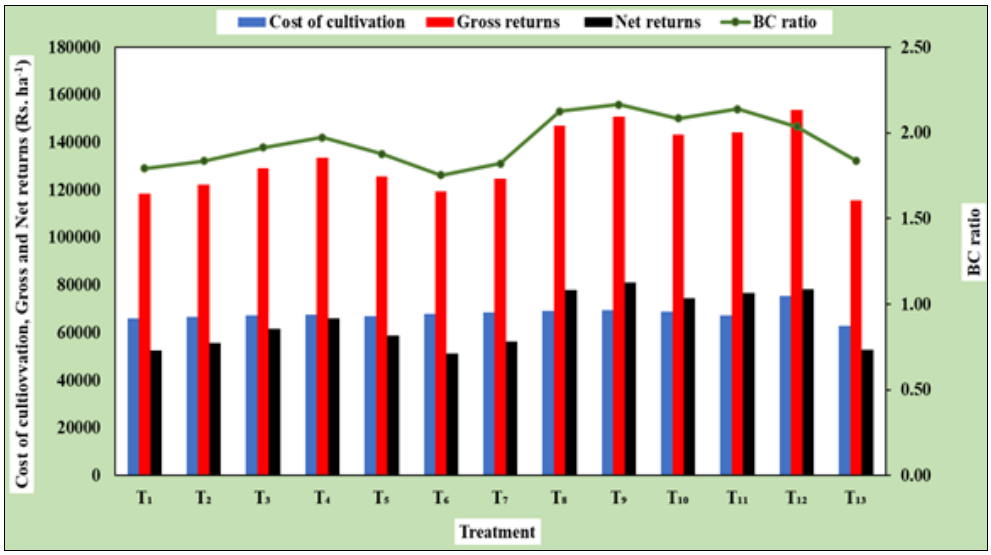

Fig 1: Economics of groundnut production as influenced by different weed management practices

Conclusion

Higher weed control efficiency at all stages of crop growth, significantly higher pod yield (2665 kg ha^{-1}), lower weed index (1.96%) and oil yield (945 kg ha^{-1}), significantly higher gross returns ((Rs.1,50,737 ha^{-1}), net monetary returns (Rs.81,152 ha^{-1}) and benefit-cost ratio (2.17) was recorded with the treatment pre-emergent application of Diclosulam 84% WDG @ 31.25 g *a.i.* ha^{-1} *fb* post-emergent application of Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS followed by application of Diclosulam 84% WDG @ 25.00 g *a.i.* ha^{-1} (PE) *fb* Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS (POE), Pendimethalin 38.7% CS @ 677.25 g *a.i.* ha^{-1} (PE) *fb* Propaquizafop 2.5% + Imazethapyr 3.75% w/w ME @ 125 g *a.i.* ha^{-1} at 18-20 DAS (POE) and IC at 20 and 40 DAS *fb* one hand weeding at 30 DAS. Further, weedy check recorded lower weed control efficiency, significantly lower pod yield, oil yield and economics of groundnut production.

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