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Growth and Yield Attributes of Groundnut (*Arachis hypogaea* L.) as Influenced by Tank-mix Application of Early Post Emergence Herbicides

S. Ravi[1], S.R. Shri Rangasami[2], N. Vadivel[3], R. Ajaykumar[4], K. Harishankar[5]

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ABSTRACT

Background: Groundnut or peanut (*Arachis hypogaea* L.) is known as the 'king' of oilseeds. It is one of the most important food and cash crop of India. Among different constraints that limit the productivity of groundnut, weed menace is one of the serious bottlenecks. A field experiment was conducted at Perunthalaivar Kamaraj Krishi Vigyan Kendra, Puducherry during 2019 to 2020 to study the tank mix application of post-emergence herbicides for efficient weed control in Groundnut.

Methods: The experiment was laid out in randomized block design with 13 treatments and replicated thrice. The treatments consisted of weed management practices *viz*., pre emergence herbicide pendimethalin and post emergence herbicide *viz*., imazethapyr, quizalofop-ethyl and those herbicides used either alone or combined with hand weeding once. In addition, hand weedings twice at 15 and 30 DAS were tested with unweeded check.

Result: The experiment results of the two years study revealed that the Pendimethalin @ 1.5 kg ai ha^{-1} (PE) + tank mix of Imazethpyr (40%) + Quizalofop ethyl (60%) at 20-30 DAS recorded maximum plant height (58.17 cm), DMP (36.81 g $plant^{-1}$), Significantly higher pod yield (3752 kg ha^{-1}), highest net income (` 90,762 ha^{-1}) and B:C ratio (2.80). Correlation and Regression analysis also indicated that the yield attributes had a positive impact on groundnut yield.

Key words: Correlation, Economics, Groundnut, Growth, Herbicides, Regression, Yield.

INTRODUCTION

Groundnut (*Arachis hypogea* L.) is an important oilseed crop in the tropical and subtropical regions of the world. It is a unique crop, matching the attributes for both legume and oilseed crop. Groundnut is one of the principal economic plants as a resource for edible oil and protein. India is the second largest producer of groundnut in the world. Among different constraints that limit the productivity of groundnut, weed menace is one of the serious bottlenecks (Sanbagavalli *et al*., 2016). The weeds emerge fast, grow rapidly competing with the crop severely for the resources namely nutrients, sunlight and space, soil moisture and reduce the crop yield. Competitional stress of weeds exerts reduction in pod yield to the extent of 17-84% (Priyadarshini *et al.,* 2023). Thus weed management is essential to get optimum crop yield. Manual or mechanical methods of weed control after sowing will be less effective, laborious and time consuming and need to be repeated at regular intervals. Manual weeding is always not possible, because of greater demand for labour and heavy rainfall in monsoon season resulting in severe weed competition (Uygur *et al*., 2010) Therefore, chemical weed control is considered to be an alternative for effective and economic weed management. Use of correct herbicides will provide completely weed-free situation to the crop whereas manual or mechanical weeding can be done only after the emergence of weeds (Rashid *et al*., 2012). Chemical weed control by pre-emergence and post-emergence application of herbicide and combinations of them are all competitive and promising way to control weeds, at least for first few weeks after sowing of crop (Manda, 2011). Herbicide discovery and development is a continuing process, because there is always a need for newer herbicides to meet the changing weed situations in agricultural systems to achieve greater efficacy and economy in chemical weed control and to minimize risks through toxicity and residues to the environment (Hossain, 2015). In the light of the above facts, present investigation

[1]Krishi Vigyan Kendra, Puducherry-605 009, Tamil Nadu, India.
[2] Krishi Vigyan Kendra, Tamil Nadu Agricultural University, Tiruppur-641 667, Tamil Nadu, India.
[3]Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu, India.
[4]Department of Agronomy, Vanavarayar Institute of Agriculture, Pollachi-642 103, Tamil Nadu, India.
[5]S. Thangapazham Agricultural College, Tenkasi-627 758, Tamil Nadu, India.

Corresponding Author: S.R. Shri Rangasami, Krishi Vigyan Kendra, Tamil Nadu Agricultural University, Tiruppur-641 667, Tamil Nadu, India. Email: shrirangasamisr@tnau.ac.in

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aims to study the tank mix application of post-emergence herbicides for efficient weed control in groundnut

MATERIALS AND METHODS

A field experiment was conducted at Perunthalaivar Kamaraj Krishi Vigyan Kendra, Puducherry during 2019 to 2020 to evaluate the performance of weed management practices/ techniques on growth and yield of groundnut. The soil of the experimental field was sandy clay loam in texture, low in available nitrogen, medium in available phosphorus and high in available potassium. The experiment was laid out in randomized block design with 13 treatments and replicated thrice. The treatments consisted of weed management practices *viz*., T_1: Weedy check (Control), T_2: Farmers practice (Hand weeding at 15 and 30 DAS), T_3: Pendimethalin @ 1.5 kg ai/ha (PE) + One hand weeding at 25 DAS, T_4: Pendimethalin @1.5 kg ai/ha (PE) + Imazethpyr @ 75 g ai/ha at 20- 30 DAS, T_5: Pendimethalin @1.5 kg ai/ ha (PE) + Quizalofop ethyl @ 50 g ai/ha at 20- 30 DAS, T_6: Pendimethalin @1.5 kg ai/ha (PE) + tank mix of Imazethpyr (50%) + Quizalofop ethyl (50%) at 20-30 DAS, T_7: Pendimethalin @ 1.5 kg ai/ha (PE)+ tank mix of Imazethpyr (60%) + Quizalofop ethyl (40%) at 20-30 DAS, T_8: Pendimethalin @ 1.5 kg ai/ha (PE)+ tank mix of Imazethpyr (40%) + Quizalofop ethyl (60%) at 20-30 DAS, T_9: Tank mix of Imazethpyr (50%) + Quizalofop ethyl (50%) at 20- 30 DAS, T_{10}: Tank mix of Imazethpyr (60%) + Quizalofop ethyl (40%) at 20- 30 DAS, T_{11}: Tank mix of Imazethpyr (40%) + Quizalofop ethyl (60%) at 20-30 DAS, T_{12}; Weed free.

The seeds of groundnut were treated with *Trichoderma viride* at the rate of 2 g/kg of seed. Seeds were sown in lines at 30 cm apart and 10 cm between plants. The entire dose of recommended fertilizers (17:34:54 kg NPK ha^{-1}) were applied basally before sowing in the form of urea, single super phosphate and muriate of potash. Gypsum at the rate of 400 kg ha^{-1} was applied in two equal splits, one at basal and another at the time of earthing up on 40 DAS. All other agronomic practices were adopted as per the need of the crop.

Absolute and relative density of individual group wise weeds was calculated by the method suggested by Kim and Moody (1983). Weed control efficiency was worked out on the basis of weed dry weight recorded in each treatment at harvest stage, using the formula suggested by Sankaran and Mani (1974). Ten plants were selected at random in each plot and were tagged for recording the observations of the growth, yield attributes and yield. Crop was harvested at maturity, threshed and plot-wise seed and a yield in kg ha^{-1} was recorded. The data on the different parameters was analyzed statistically by adopting Fisher's method of ANOVA suggested by Gomez and Gomez (2010).

Quantitative variables analysis

Correlation and multiple linear regressions were employed to study the value of money or profitability, the relationship between the various parameters (variables) and seed yield. The Pearson Correlation Coefficient (PCC) is the most prevalent sort of correlation coefficient and it creates a relationship between expected and observed values after a statistical investigation (Ihsan *et al*., 2015). The study utilized correlation analysis to examine the relationships among several variables, including grain yield (kg ha^{-1}), pods $plant^{-1}$ (No.), 100 kernel weight (gm), shelling (%), SMK (%), plant height (cm), dry matter production (kg/ha) and weed control efficiency (%) (Ajaykumar *et al*., 2023). It was computed using the equation,

$$r_{xy} = \frac{S_{xy}}{S_x S_y} = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 (E(y_i - \bar{y})^2)}}$$

Where,

r_{xy}= Coefficient of the linear relationship between the variables x and y.

S_x and S_y= Sample standard deviation.

S_{xy}= Sample covariance.

x_i and y_i= Values of x and y variables in the sample of the population.

$\bar{x}$ and $\bar{y}$= Sample mean.

The study also employed regression analysis as an econometric tool to investigate the association between a dependent variable and a set of independent variables. Regression analysis was performed by:

Grain yield (Kg ha^{-1}) =

$$\alpha + \beta_1 \text{ pods /plant (No's)} + \beta_2 \text{ 100 kernel weight (gm.)} + \beta_3 \text{ shelling (\%)} + \beta_4 \text{ SMK (\%)} + \beta_5 \text{ plant height (cm)} + \beta_6 \text{ dry matter production (g/ plant)} + \beta_7 \text{ weed control efficiency (\%)} + u_i$$

RESULTS AND DISCUSSION

Weed flora of the experimental field

The common weed flora of the experimental field consisted of grasses, sedges and broad leaved weeds were presented in Table 1. The absolute density and relative density of individual group of weeds were recorded at 30 DAS. Among the group of weeds, broad leaved weeds recorded higher relative density of 43.3 per cent with an absolute density of 27.0 No./m^2 (Table 1). It was followed by grass weeds (Relative density 35.3 per cent, absolute density 22.0 no./m^2). Sedge weeds recorded the lower relative density of 21.4 per cent having an absolute density of 13.3 no./m^2.

Weed characters

Total weed density, weed dry weight and weed control efficiency were presented in Table 2. Application of Pendimethalin @ 1.5 kg ai/ha (PE) + tank mix of Imazethpyr (40%) + Quizalofop ethyl (60%) at 20-30 DAS has significantly recorded the lesser total weed dry weight of 718 kg ha^{-1} and higher weed control efficiency of 75per cent which was followed by Pendimethalin @1.5 kg ai ha^{-1} (PE) + tank mix of Imazethpyr (50%) + Quizalofop ethyl (50%) at 20-30 DAS.This might be due to the combined effect of pre and early post emergency herbicide which reduce the

early establishment of weeds in groundnut and effective crop smothering by groundnut (Singh and Dhillon, 2023).

Consequently the lower weed control efficiency and higher total weed dry weight of 2868 kg ha^{-1} was registered in treatment T_1 (weedy check - Control) at harvest stage respectively. This might be due to the uncontrolled weed germination because of no weed control measures and continuous supply of nutrients for weed growth by tank-mix application of early post emergence herbicides (Das *et al*., 2012).

Growth and yield

The results revealed that all the weed-control measures including weed-free control significantly improved the growth and yield characters, except plant population, over unweeded control (Table 3). Application of Pendimethalin @ 1.5 kg *ai* ha^{-1} (PE) + tank mix of Imazethpyr (40%) + Quizalofop ethyl (60%) at 20-30 DAS revealed that the maximum plant height (58.17 cm), Dry Matter Production (36.81 g plant) at harvest stage, pod yield (3906 kg ha^{-1}) and haulm yield (5204 kg ha^{-1}) which was followed by Pendimethalin @ 1.5 kg ai ha^{-1} (PE) + tank mix of Imazethpyr (50%) + Quizalofop ethyl (50%) at 20-30 DAS had positive response to increase the pod yield (3752 kg ha^{-1}) and the lowest plant height (50.01 cm) and Dry Matter Production (25.10 g/plant) was observed with weedy check (Control). The reason might be due to better weed control by optimum usage of herbicide, which provided conducive environment favoring higher nutrient uptake that reflected on higher plant height, leaf area index and better source sink relationship. Unweeded control resulted in shorter plants, obviously due to the competitive effect of weeds throughout the crop growth. All the growth-attributing characters, which were dominant in different weed control methods, favoured to bear more number of pods than weedy check (Das *et al*., 2012).

The lesser yield reduction due to above weed management practices might be due to minimum weed growth and it provides favorable environment enhanced the yield levels. The maximum yield reduction was observed with weedy check. It is in accordance with the finding of (Kumar *et al*., 2008) who reported the largest yield reduction of 66.34 per cent under weedy check in soybean. Groundnut

Table 1: Pre dominant weed flora of the experimental field.

Weed group	Weed species	Family	Absolute weed density (No./m^2)	Relative weed density (per cent)
Grasses	*Cynodon dactylon*	Poaceae	22.0	35.3
	Panicum javanicum			
	Digitaria bicornis			
	Ischaemum indicum			
	Echinocloa colonum			
Sedges	*Cyperus rotundus*	Cyperaceae	13.3	21.4
Broad leaved weeds	*Parthenium hysteroporus*	Asteraceae	27.0	43.3
	Portulaca oleracea	Portulacaceae		
	Acalypha indica	Euphorbiaceae		
	Boerhaevia erecta	Nyctaginaceae		
	Digeria arvensis	Amaranthaceae		
	Total weed density		62.3	100.0

Table 2: Effect of weed management practices on weed characters of groundnut at harvest stage.

Treatment	Total weed density (No./ m^2)	Weed dry weight (kg ha^{-1})	Weed control efficiency (%)
T_1	11.05 (121.67)	2868	0.0
T_2	5.90 (34.33)	852	70.3
T_3	6.28 (39.00)	826	71.2
T_4	7.13 (50.33)	808	71.5
T_5	6.57 (42.67)	818	71.8
T_6	6.62 (43.33)	734	74.4
T_7	6.47 (41.33)	736	74.3
T_8	6.79 (45.67)	718	75.0
T_9	6.01 (35.67)	788	72.5
T_{10}	7.60 (57.33)	1560	45.6
T_{11}	6.10 (36.67)	1686	41.2
T_{12}	8.36 (69.33)	800	72.1
SEd	6.86	48	3.4
CD (P=0.05)	NS	100	7.1

being a deep-rooted legume crop proliferation of the root at early stage is essentially required to establish the sufficient numbers of nodule and better crop growth for pegging. Weed growth is faster than crop growth at early stage so controlling of weeds at early stage reduced the crop weed competition and thus providing nutritional security to the crop as result of better pod yield.

Yield attributes

Effect of different herbicidal treatments on yield attributing characters of groundnut was found to be significant (Table 4). Application of Pendimethalin @ 1.5 kg ai/ha (PE) + tank mix of Imazethpyr (40%) + Quizalofop ethyl (60%) at 20-30 DAS has recorded the highest pod plant^{-1} (32.5 No.), test weight (57.6 g), shelling (73.02 %) and sound mature kernels (90.18 %) which was followed by Pendimethalin @ 1.5 kg ai/ha (PE) + tank mix of Imazethpyr (50%) + Quizalofop ethyl (50%) at 20- 30 DAS and the lowest pod plant^{-1} (18.5 No.), test weight (51.4 g), shelling (65.18%) and sound mature kernels (82.53%) was observed with weedy check (Control). This might due to weed free environment and effective utilization of applied inputs and natural resources by the crop. When weeds were not controlled up to the critical period of crop, weed competition on plants for crop growth resources occur leading to inferior yield attributing traits like matured pods/plant and kernel weight. This would have reflected in poor pod yield under unweeded control. Presence of weeds throughout the growing season caused poor crop growth and yield reduction in unweeded check. The results are in accordance with the findings of (Kalhapure *et al*., 2013).

Economics

Higher crop productivity with lesser cost of cultivation could result in better economic parameters like gross returns, net returns and B: C ratio (Table 5). The effect of different

Table 3: Effect of weed management practices on growth and yield of groundnut at harvest stage (Pooled data).

Treatment	Plant height (cm)	DMP (g^{-1} plant)	Dry pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
T_1	50.01	25.10	2412	3806
T_2	54.17	32.22	3050	4224
T_3	54.73	33.11	3225	4292
T_4	55.57	33.18	3229	4302
T_5	55.74	32.75	3274	4451
T_6	58.16	35.96	3752	5180
T_7	56.88	36.27	3691	5054
T_8	58.17	36.81	3906	5204
T_9	55.29	33.06	3343	4282
T_{10}	52.74	29.77	2823	4167
T_{11}	52.73	28.18	2705	3748
T_{12}	55.53	33.88	3309	4534
S.Em±	1.06	0.63	104	86
LSD (P=0.05)	3.11	1.86	307	252
CV (%)	3.34	3.35	5.38	3.36

Table 4: Effect of weed management practices on yield attributes of groundnut (Pooled data).

Treatment	Pods/plant (No.)	100 kernel weight (g)	Shelling (%)	SMK (%)
T_1	18.5	51.4	65.18	82.53
T_2	26.2	54.1	68.73	85.99
T_3	27.4	54.6	69.68	86.88
T_4	27.0	55.8	70.60	87.71
T_5	27.7	54.5	70.63	87.84
T_6	31.2	57.2	72.83	89.60
T_7	31.8	56.6	72.88	89.21
T_8	32.5	57.6	73.02	90.18
T_9	26.7	54.8	71.29	86.68
T_{10}	22.7	53.7	68.03	84.71
T_{11}	21.4	52.8	67.33	84.24
T_{12}	27.9	55.3	68.93	87.85
S.Em±	0.53	1.05	1.35	1.69
LSD (P=0.05)	1.55	3.09	3.97	4.95
CV (%)	3.40	3.31	3.33	3.41

treatments on the economics of groundnut cultivation showed that Pendimethalin @ 1.5 kg ai ha^{-1} (PE) + tank mix of Imazethpyr (40%) + Quizalofop ethyl (60%) at 20-30 DAS recorded higher net returns (` 90762 ha^{-1}) and B:C ratio (2.80) and followed by Pendimethalin @ 1.5 kg ai ha^{-1} (PE) + tank mix of Imazethpyr (50%) + Quizalofop ethyl (50%) at 20- 30 DAS. The increased income realized with these two treatments might be due to higher pod yield obtained due to the treatment efficiency, which would have reduced the competition between weeds and crop for water and nutrients. The results are analogous to those reported by Naim *et al*. (2010). Though the traditional method of hand weeding effectively minimizes the weed competition and maximizes the yield and higher net return, the B: C ratio would be less compared to above mentioned weed control treatment. This might to be more labor and higher wages resulted in higher cost of cultivation.

Correlation and regression analysis

The correlation results revealed that all the variables included in the model were positively significant at a one percent level of significance (Table 6). These findings suggest that each variable contributes to the groundnut's grain yield. As grain yield is the most critical variable that directly reflects the yield, it was compared with other plant-related parameters to determine their relationship with each

Table 5: Effect of weed management practices on economics of groundnut (Pooled data).

Treatment	Cost of cultivation (` ha^{-1})	Gross returns (` ha^{-1})	Net returns (` ha^{-1})	Benefit cost ratio
T_1	48097	88056	39961	1.82
T_2	55597	110967	55372	1.98
T_3	52949	117225	64278	2.20
T_4	50444	117213	66771	2.33
T_5	51327	118858	67532	2.34
T_6	50884	136564	85680	2.67
T_7	50797	134056	83259	2.66
T_8	50972	141734	90762	2.80
T_9	49782	121018	71237	2.47
T_{10}	49694	102849	53155	2.07
T_{11}	49869	98332	48462	1.97
T_{12}	59347	120337	61442	2.02
SEd	1070	1813	1206	0.05
CD (P=0.05)	2190	3712	2482	0.12

Table 6: Correlation between yield attributes and growth characters of groundnut (Pooled data).

Variables	Yield (Kg/ha)	Pods/plant (No.)	100 kernel weight (g)	Shelling (%)	SMK (%)	Plant height (cm)	DMP (g/plant)	WCE (%)
Yield (kg/ha)	1.00	0.77	-0.06	0.86	0.01	0.93	0.96	0.47
Pods/plant (no.)		1.00	-0.09	0.70	-0.01	0.72	0.76	0.38
100 kernel weight (g)			1.00	-0.02	0.04	-0.02	-0.03	0.16
Shelling (%)				1.00	0.09	0.83	0.83	0.28
SMK (%)					1.00	-0.02	-0.03	-0.20
Plant height (cm)						1.00	0.93	0.45
DMP (g/plant)							1.00	0.52
WCE (%)								1.00

Table 7: Multiple linear regression estimates the groundnut yield.

Source	Value	Standard error	T stat	P value
Intercept	-3631.56	951.37	-3.81	0.000
Pods/plant (No.s)	47.03**	14.60	3.22	0.002
100 kernel weight (gm)	9.51	14.52	0.65	0.515
Shelling (%)	17.74*	8.40	2.11	0.040
SMK (%)	12.95	8.25	1.57	0.123
Plant height (cm)	26.30**	10.21	2.57	0.009
Dry matter production (g/plant)	45.58**	19.27	2.36	0.022
Weed control efficiency (%)	-3.54**	1.21	-2.91	0.005

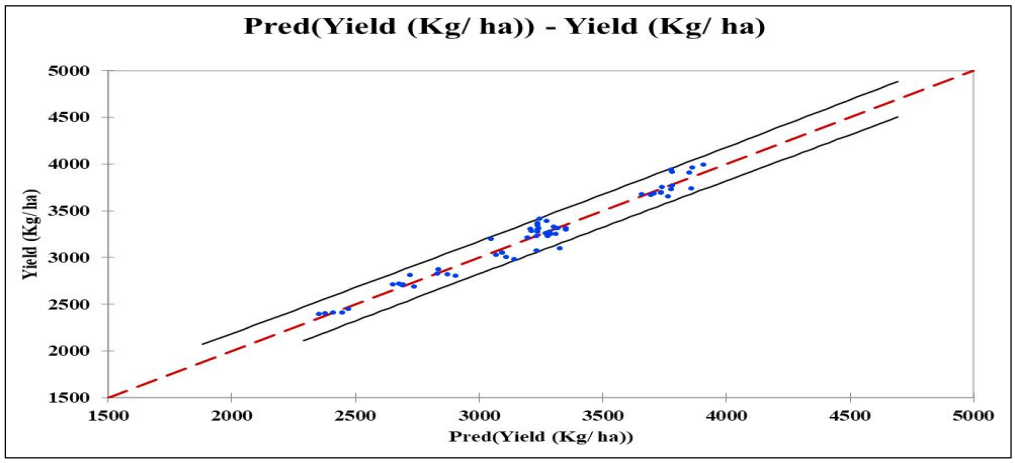


Fig 1: Regression Fit: groundnut yield *versus* predicted groundnut yield.

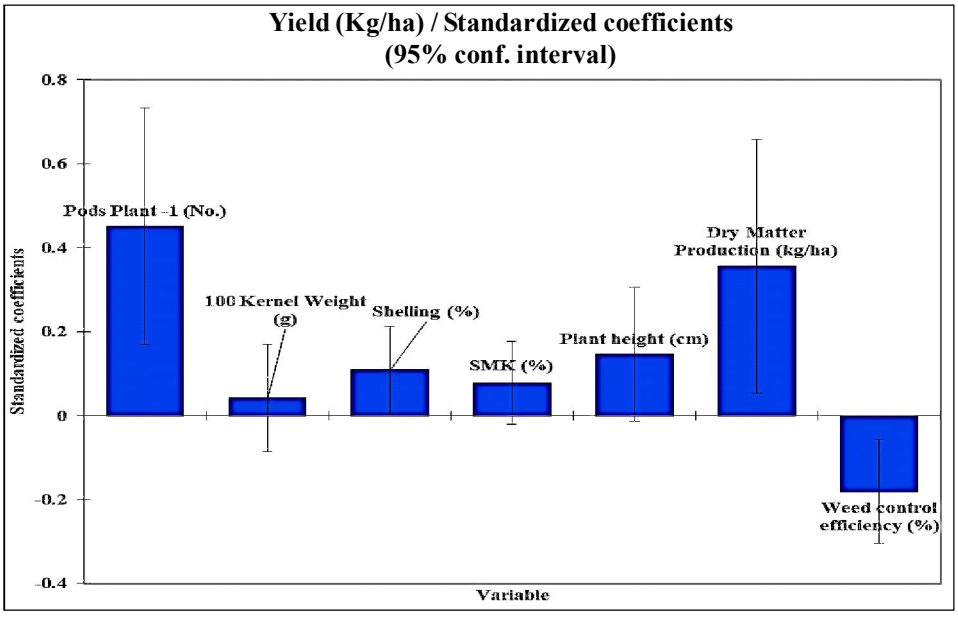


Fig 2: Standardized regression coefficients of the yield attributes and growth characteristics of groundnut.

other. The correlation coefficients indicated that grain yield positively correlated with pods per plant (0.77), shelling (0.86), plant height (0.93), dry matter production (0.96) and weed control efficiency (0.47), except for 100 seed kernel weight (Kiani *et al.,* 2020). Therefore, all of these variables were included as independent variables in the multiple linear regression model (Ajaykumar *et al*., 2022). Multiple linear regressions, which were employed to measure the relationship and the magnitude of the change in grain yield due to the other prescribed parameters. The multiple linear regression equation could be written as:

Grain yield=

-3631.56 + 47.03 pods/plant (No's) + 9.51 100 kernel weight (gm) + 17.74 shelling (%) + 12.95 SMK (%) + 26.30 plant height (cm) + 45.58 dry matter production (gm/plant) -3.54 weed control efiiciency (%)

The R^2 value of 0.76 indicated a good fit for the model, suggesting that the independent variables accounted for 76 percent of the grain yield (Table 7). Except for 100 kernel weight (gm) and SMK (%), all variables were found to be statistically significant. The slope coefficient of pods per plant revealed that a one per cent increase in pods per plant would lead to a significant 47.03 per cent increase in yield, holding all other variables constant. Similarly, a one per cent increase in shelling (%), plant height (cm), dry matter production (g/plant) and weed control efficiency (%) would result in yield increases of 17.14, 26.30 and 45.58 per cent, respectively (Tittonell *et al*., 2008). However, an increase in weed control efficiency resulted in a negative impact on yield, with a one per cent increase causing a 3.54 per cent decrease in yield. Additionally, Fig 1 and 2 depicts the standard coefficients of the independent variables pertinent to the grain yield in the regression analysis.

CONCLUSION

Both the years of experiments concluded that the application of Pendimethalin @ 1.5 kg ai/ha (PE) + tank mix of Imazethpyr (40%) + Quizalofop ethyl (60%) at 20-30 DAS significantly increased growth characters, yield attributes and yield compared to all other treatments. Hence it can be recommended that application of Pendimethalin @ 1.5 kg ai/ha (PE) + tank mix of Imazethpyr (40%) + Quizalofop ethyl (60%) at 20-30 DAS are the most effective broad spectrum weed management practices to increase the economic yield and monetary returns in groundnut at the times of labor short comes. The correlation and regression results showed that all the parameters had a positive relation on the grain yield and thus variables should be focused to enhance the productivity of the groundnut.

Conflict of interest: None.

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