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Weed Dynamics and Crop Productivity as Influenced by Weed Management Practices and Fertility Levels in Groundnut (*Arachis hypogaea* L.)

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ABSTRACT

Background: Groundnut or peanut (*Arachis hypogaea* L.) is known as the “King of Oilseeds” which belongs to family Fabaceae (Leguminosae). It is highly susceptible to weed infestation because of its slow initial growth up to 40 DAS and small foliage cover. However, study on use of mechanical weed control methods with different fertility regimes for improving the productivity of groundnut was limited. Therefore, the objective of this study was to find a suitable method for optimising the productivity of groundnut.

Methods: A field experiment was conducted at Odisha University of Agriculture and Technology, Bhubaneswar for two consecutive years of 2020 and 2021. The field experiment comprised 16 treatment combinations of four weed management practices and four fertility levels. The weed management practice included W_1-Pre-emergence (PE) application of pendimethalin @ 0.75 kg ha^{-1}, W_2-Pre-emergence (PE) application of pretilachlor @ 0.5 kg ha^{-1}, W_3-Manual weeding (20 and 40 DAS), W_4-Twin wheel hoe at 20 DAS followed by (*fb*) hand weeding at 40 DAS and four fertility levels includes T_1-100% RDF (20:40:40) (N: P_20_5: K_2O kg ha^{-1}), T_2- 75% RDF + 5 tonnes FYM ha^{-1}, T_3- 50% RDF + 10 tonnes FYM ha^{-1}, T_4- without fertilizer + without FYM.

Result: Amongst the weed management practices, use of twin wheel hoe at 20 DAS followed by hand weeding at 40 DAS significantly reduced the weed density, weed dry weight, weed index and recorded the highest weed control efficiency (69.8%). Highest weed index (32.9) was recorded with the application of pretilachlor @ 0.5 kg ha^{-1} (PE), which was followed by weed index of (28.5) with application of pendimethalin @ 0.75 kg ha^{-1} (PE). The fertilizer management practice with application of 50% RDF + 10 tonnes FYM ha^{-1} gave the highest yield and considerably reduced the total weed density, weed dry weight and recorded the maximum weed control efficiency (71.8 % at harvest). We suggest that weed management with twin wheel hoe at 20 DAS followed by hand weeding at 40 DAS along with application of 50% RDF + 10 tonnes FYM ha^{-1} as the most effective strategy for controlling the weed menace in groundnut with the highest weed control efficiency.

Key words: B:C ratio, Weed control efficiency, Weed density, Weed index, Yield.

INTRODUCTION

Groundnut or peanut (*Arachis hypogaea* L.) is known as the “King of Oilseeds” which belongs to the family Fabaceae (Leguminosae). Commercially and nutritionally it is very important source of oil (49%) and protein (26%) (Suseendran *et al*., 2019). The growing demand for groundnut has led to an increased global cultivated area and export. In India, groundnut is grown in an area of 4.89 M ha with a production of 10.10 million tonnes and an average productivity of 2065 kg ha^{-1} (Agricultural Statistics at a Glance, 2020). India was the world’s leading exporter of groundnut oil in financial year 2021 (https://www.statista.com/). In Odisha, groundnut occupied an area of 2.05 lakh hectare with a production of 388 thousand tonnes and an average productivity of 1894 kg ha^{-1} (Odisha Economic Survey, 2020-21).

Chaudhary *et al.* (2015) reported that groundnut is highly responsive to fertilizer application. Indiscriminate use of inorganic fertilizers create problem of multi-nutrient deficiencies which results in low yield. Thus, to optimize the production of groundnut, the nutritional needs of the crop must be satisfied through conjunctive use of microbial, organic and inorganic fertilizers to attain higher yields (Mohapatra and Dixit, 2010 and Chavan *et al*., 2014).

Weeds cause severe loss in groundnut and hinder realising potential yield. For instance, weed infestation resulted in 35.8% yield loss in groundnut (Gharde *et al*., 2018). Groundnut requires efficient weed management at

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initial growth stage because of its slow initial growth up to 40 DAS and small foliage cover (Jat *et al*., 2011). Weed management methods like hand weeding and hoeing are mostly practiced to control weeds in groundnut but they have certain limitations such as unavailability and scarcity of labourers during peak period and hike in the labour wages. After peg initiation, the use of mechanically operated power weeder is detrimental to the crop. On the other hand, use of herbicides is also limited due to their selectivity in controlling weeds in groundnut. The maximum benefit can be achieved by combining herbicides with manual, cultural and mechanical weed control methods (Reddy *et al*., 2016). Combination of both chemical and physical methods throughout the crop growth period efficiently controlled weeds in groundnut (Kalhapure *et al*., 2013).

Keeping in view the nutrient requirement of groundnut and higher cost involved in weed control, the present study was undertaken to formulate a suitable weed control measure in relation to varying fertility regimes for improving the productivity of groundnut.

MATERIALS AND METHODS

Experimental site

The present field experiment was conducted at AICRP on weed management Block, Central farm, Odisha University of Agriculture and Technology, Bhubaneswar (20°15′N latitude and 85°52′E longitude), India. The study site falls under hot and humid climate with mean annual rainfall of 1467 mm. The dry or summer season ranges from January to May with mean maximum temperature of 34.1°C. The soil belongs to the order *Alfisols* with sandy clayey loam texture. Chemical analysis of upper 15 cm soil showed low organic carbon (0.38%) and low available nitrogen (194.6 kg ha^{-1}), low phosphorus (11.2 kg ha^{-1}) and medium potassium (198.4 kg ha^{-1}) and acidic soil reaction (pH 4.8, 1:2.5 soil: water). Lime has been applied at 0.2 LR (350 kg ha^{-1}) before sowing in both the years.

Experimental details and crop management

The experiment was conducted in factorial randomized complete block design with three replications in the summer seasons (January-April) for two consecutive years in 2020 and 2021. The field experiment comprised of 16 treatment combinations of four weed management practices and four fertility levels. The weed management practice includes W_1- Pre-emergence (PE) application of pendimethalin @ 0.75 kg ha^{-1}, W_2- Pre-emergence (PE) application of pretilachlor @ 0.5 kg ha^{-1}, W_3- Manual weeding (20 and 40 DAS), W_4- Twin wheel hoe at 20 DAS followed by (*fb*) hand weeding at 40 DAS and four fertility levels includes T_1-100% RDF (20:40:40) (N: P_20_5: K_2O kg ha^{-1}), T_2- 75% RDF + 5 tonnes FYM ha^{-1}, T_3- 50% RDF + 10 tonnes FYM ha^{-1}, T_4- without fertilizer + without FYM. The crop was fertilized as basal with FYM and recommended dose of fertilizer 20 kg N, 40 kg P_2O_5 and 40 kg K_2O ha^{-1} as per treatment through Urea, Single super phosphate and Muriate of potash, respectively. Groundnut cultivar "ICGV91114" (Devi) was sown at a spacing of 30 cm × 10 cm on 6th January 2020 and 5th January 2021 with the same treatments.

The crop was sown with the seed rate of 150 kg ha^{-1}. Kernels were treated with Thiram @ 2 g kg^{-1} kernel seven days before sowing to prevent seed borne disease. One day before sowing, the kernels were again treated with rhizobium @ 20 g kg^{-1} kernel. Hand weeding was done with hand hoes at 20 and 40 days after sowing according to the treatments. First irrigation was given one day after sowing to ensure uniform germination. Then subsequently six irrigations were given at different crop growth stages as and when required. The crop was harvested on 30th April 2020 and 2021, respectively. Important observations were recorded at the appropriate time.

Herbicide description and management

The pre-emergence herbicides like pendimethalin (Dhanutop) and pretilachlor (Dhanuka) were applied as pre emergence at 2-3 days after sowing. Herbicides were applied by a hand operated backpack knapsack sprayer of 16 litre capacity with a flat fan nozzle. The amount of water used for dilution was 500 l ha^{-1}.

Weed density, dry weight and weed indices

Species wise density and dry weight of weeds were assessed at 30 DAS and harvest from each plot using a quadrate size of 0.25 m^2 (0.5 m × 0.5 m). Two quadrates were selected randomly in each plot. Weeds collected from a 0.25 m^2 area were identified, counted species-wise and expressed as no. m^{-2}. Identified weeds were sun-dried for 3 days and kept in electric oven at 70°C. Dry weight was expressed as g m^{-2}. Weed control efficiency (Das, 2008) and weed index (Gill and Kumar, 1969) were calculated as per the following formulae:

$$\text{Weed control efficiency (\%)} = \frac{X - Y}{X} \times 100$$

Where,

X: Weed dry matter production in weedy plot.

Y: Weed dry matter production in treated plot.

$$\text{Weed index} = \frac{A - B}{A} \times 100$$

Where,

A: Seed yield of the best treatment.

B: Seed yield of the particular treatment for which the index is computed.

Crop growth and yield estimation

Nodule number, dry weight of the plant and nodules were estimated at 40 DAS in both the years 2020 and 2021. Five plants were randomly selected from each plot and nodules were counted. Plants were sun dried and kept in electric oven at 70°C for 72 h weighed and the dry weight was expressed in g $plant^{-1}$. Groundnut was harvested from the central net area (2 m × 2 m) for yield estimation. The seed yield of groundnut was expressed in kg ha^{-1}.

Statistical analysis

Data was analysed for factorial randomized complete block design (Gomez and Gomez, 1984). Before analysis of variance estimation, all data were subjected to test of homogeneity of error variances. Treatment means were compared using a protected least significant difference test at $p \leq 0.05$.

RESULTS AND DISCUSSION

Groundnut growth parameters

Weed management practices with twin wheel hoe at 20 DAS *fb* hand weeding at 40 DAS had significant effect on growth parameters of groundnut in terms of plant height (36.4 cm), number of branches per plant (6.5) and number of nodules per plant (93.7) (Table 1).

Among the different fertility levels, application of 50% RDF + 10 tonnes FYM ha^{-1} recorded significantly highest plant height (37.6 cm), number of branches per plant (6.5) and number of nodules per plant (105.3) (Table 1).

Groundnut yield attributes and yield

The yield attributing characters with twin wheel hoe at 20 DAS *fb* hand weeding at 40 DAS were significantly higher over other treatments. It resulted in increased pod and haulm yield by 6.9% and 4.7%, respectively over manual hand weeding (20 and 40 DAS) (Table 2).

Significantly maximum yield attributes and yield like number of pods per plant (19.3), hundred pod weight (97.5 g), numbers of kernels pod^{-1} (1.9) and hundred kernel weight (38.8 g), pod yield (1899 kg ha^{-1}), haulm yield (3534 kg ha^{-1}), shelling percentage (73.4%) and harvest index (34.9 %) were observed with the application of 50% RDF + 10 tonnes FYM ha^{-1} (Table 2).

The interaction effect was found significant (Table 3). Among the treatment combinations, the maximum pod yield (2267 kg ha^{-1}) was obtained under weed management with twin wheel hoe at 20 DAS followed by hand weeding at 40 DAS along with application of 50% RDF + 10 tonnes FYM ha^{-1} (2013 kg ha^{-1}). Whereas, the minimum pod yield (760 kg ha^{-1}) was recorded under application of pretilachlor @ 0.5 kg ha^{-1} along with control (without fertilizer + without FYM).

Weed density and dry weight

The total weed density increased gradually up to 60 DAS and then declined subsequently till harvest (Table 4). The lowest weed density of 6.8 m^{-2} was reported with twin wheel hoe at 20 DAS followed by hand weeding at 40 DAS at harvest. There was a gradual increase in the total dry weight of weeds during the crop period till harvest of the crop. Twin wheel hoe at 20 DAS *fb* hand weeding at 40 DAS recorded the lowest total dry weight of weeds at all stages of the crop growth.

Among the fertilizer management practices, 50% RDF + 10 tonnes FYM ha^{-1} considerably reduced the total weed density (6.6 m^{-2} at harvest) and weed dry weight (8.3 g m^{-2} at harvest). Significantly highest weed density (10.5 m^{-2}) and weed dry weight (12.5 g m^{-2}) were recorded under the control (without fertilizer + without FYM) at harvest.

Weed control efficiency and weed index

Among the various weed management practices followed, the highest weed control efficiency (Fig 1) and the lowest weed index (Fig 2) were recorded with the use of twin wheel hoe at 20 DAS *fb* hand weeding at 40 DAS which was 51% effective than use of pretilachlor. The highest weed index (32.9) was recorded with the application of pretilachlor @ 0.5 kg ha^{-1} (PE), which was followed by weed index of (28.5) with application of pendimethalin @ 0.75 kg ha^{-1} (PE).

Table 1: Effect of different weed management practices and fertility levels on growth attributes of groundnut (Pooled data for 2020 and 2021).

Treatments	Plant height (cm) at harvest	No. of branches per plant at harvest	No. of nodules per plant at 40 DAS
Weed management practices			
Pendimethalin @ 0.75 kg ha^{-1} (PE)	32.4	4.5	78.9
Pretilachlor @ 0.5 kg ha^{-1} (PE)	28.9	4.0	64.7
Manual weeding (20 and 40 DAS)	35.7	6.2	88.4
Twin wheel hoe at 20 DAS *fb* hand weeding at 40 DAS	36.4	6.5	93.7
SEm±	0.95	0.17	2.40
CD (P=0.05)	3.8	0.6	8.2
Fertility levels			
100% RDF	33.5	5.6	75.7
75% RDF + 5 tonnes FYM ha^{-1}	36.9	6.2	87.5
50% RDF + 10 tonnes FYM ha^{-1}	37.6	6.5	105.3
Without fertilizer + without FYM	25.8	3.5	57.5
SEm±	0.99	0.17	2.41
CD (P=0.05)	3.4	0.8	8.3

*RDF: Recommended dose of fertilizer for groundnut is 20-40-40 @ N-P_2O_5-K_2O kg ha^{-1}.

*SEm±: Standard error of the mean.

Table 2: Effect of different weed management practices and fertility levels on yield attributes and yield of groundnut (Pooled data for 2020 and 2021).

Treatments	No. of pods plant^{-1}	Hundred pod weight (g)	No. of kernels pod^{-1}	Hundred kernel weight (g)	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Shelling (%)	Harvest index (%)
Weed management practices								
Pendimethalin @ 0.75 kg ha^{-1} (PE)	12.6	83.8	1.7	35.6	1278	2522	66.8	33.02
Pretilachlor @ 0.5 kg ha^{-1} (PE)	12.2	81.6	1.5	34.2	1198	2483	64.5	32.54
Manual weeding (20 and 40 DAS)	16.7	96.4	1.9	38.2	1672	3256	69.7	33.92
Twin wheel hoe at 20 DAS *fb* hand weeding at 40 DAS	17.3	96.8	2.1	38.7	1788	3408	71.8	34.41
SEm±	0.46	2.63	0.04	1.03	46.31	85.80	2.19	-
CD (P=0.05)	1.45	9.02	0.1	3.7	148.2	291.92	6.8	-
Fertility levels								
100% RDF	14.7	93.5	1.7	37.6	1439	2775	67.5	34.1
75% RDF + 5 tonnes FYM ha^{-1}	17.5	96.8	1.8	38.4	1778	3385	69.6	34.4
50% RDF + 10 tonnes FYM ha^{-1}	19.3	97.5	1.9	38.8	1899	3534	73.4	34.9
Without fertilizer + without FYM	8.4	71.3	1.2	32.4	824	1990	62.3	29.2
SEm±	0.47	2.64	0.03	1.03	46.35	85.88	2.19	-
CD (P=0.05)	1.41	9.10	0.1	3.58	148.51	291.84	6.81	-

Table 3: Pod yield (kg ha^{-1}) of groundnut as influenced by different weed management practices and fertility levels.

Treatments	W_1-Pendimethalin @ 0.75 kg ha^{-1} (PE)	W_2-Pretilachlor @ 0.5 kg ha^{-1} (PE)	W_3-Manual weeding (20 and 40 DAS)	W_4-Twin wheel hoe followed by hand weeding at 40 DAS	Mean
T_1-100% RDF	1160	1094	1742	1760	1439
T_2-75% RDF + 5 tonnes FYM ha^{-1}	1540	1348	2007	2205	1775
T_3-50% RDF + 10 tonnes FYM ha^{-1}	1597	1582	2013	2267	1894
T_4-Without fertilizer + without FYM	783	760	837	900	820
Mean	1270	1196	1679	1783	
Interaction					
Sem (±)	47.89				
CD (P=0.05)	153.72				

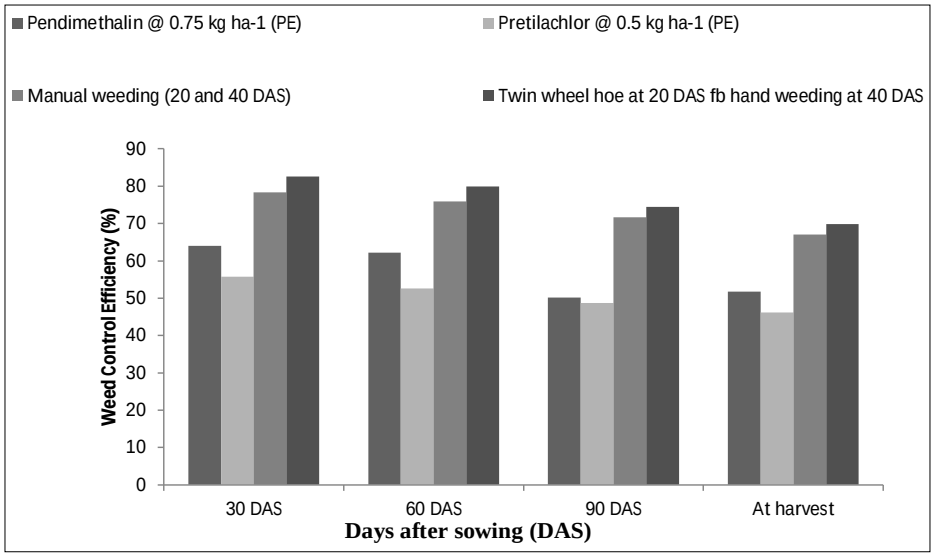

Fig 1: Weed control efficiency (%) in each herbicide treatment at various crop growth stages (Mean of 2 years).

Economics

The weed management practices by twin wheel hoe at 20 DAS followed by hand weeding at 40 DAS recorded the maximum gross returns (Rs. 92,588 ha^{-1}), net return (Rs. 37,207 ha^{-1}) and B:C (1.7) (Table 5).

Among the fertility levels, 50% RDF along with 10 tonnes FYM ha^{-1} reported maximum gross returns (Rs. 99,961 ha^{-1}). Net return (Rs. 41161 ha^{-1}) and B:C ratio (1.7).

Effect of weed management practices

Use of twin wheel hoe at 20 DAS *fb* hand weeding at 40 DAS efficiently controlled the weed growth throughout the cropping period, resulting in better environment for crop growth and development and reduced weed competition for moisture and nutrients during the critical period of crop growth. Similar results were reported by (Sanbagavalli *et al*., 2016). The highest yield attributes and yield were obtained by weeding with twin wheel hoe at 20 DAS followed by hand weeding at 40 DAS might be due to better photosynthates accumulation and absence of crop weed competition. The results are in conformity with the findings of (Kumar *et al*., 2013 and Sheoran *et al*., 2015).

The dominant weed flora of the experimental field consisted of grasses like *Digitaria sanguinalis, Digitaria ciliaris, Dactyloctenium aegyptium, Eleusine indica, Echinochloa colona* Among broadleaved weeds; *Borreria hispida, Cleome viscosa, Cleome rutidosperma, Celosia argentea, Croton sparsiflorus, Eclipta alba, Phylanthus niruri, Physalis minima, Tephrosia purpurea* and the only dominant sedge was *Cyperus rotundus.* Similar weed flora in groundnut was also reported by (Devi *et al*., 2017; Korav *et al*., 2018 and Mishra, 2020). Lower weed density and higher weed control efficiency were observed with the use of twin wheel hoe at 20 DAS *fb* hand weeding at 40 DAS might be due to the absence of weed competition during its critical growth stages of crop and availability of more light, space and nutrient to the crop. In herbicidal treatments, pendimethalin @ 0.75 kg ha^{-1} (PE) effectively reduced the total weed density at all stages of the crop growth, which was due to ability of pendimethalin to inhibit root and shoot growth of grasses. These findings corroborate the results of (Bhale *et al*., 2012; Kalaichelvi *et al*., 2015; Kirde *et al*., 2019 and Damor *et al*., 2019). Since hand weeding is cumbersome and also labour intensive, use of twin wheel hoe at 20 DAS *fb* hand weeding at 40 DAS was economic as compared to other treatments. Similar, findings have also been reported by (Sagvekar *et al*., 2015).

Effect of fertility levels

Application of 50% RDF + 10 tonnes FYM ha^{-1} effectively enhanced the growth and yield parameters. This may be because of the combined effect of FYM and recommended dose of fertilisers that enhanced the physico-chemical and biological environment of the soil. The increase in auxin supply, combined with greater nitrogen levels, most likely resulted in increased dry matter and branches per plant. Similar results were reported by (Dhadge *et al*., 2014 and

Table 4: Total weed density m^{-2} and total dry weight of weeds (g m^{-2}) at different stages of crop growth as influenced by different weed management practices and fertility levels (Pooled data for 2020 and 2021).

Treatments	Total weed density (no. m^{-2})				Total dry weight of weeds (g m^{-2})			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
Weed management practices								
Pendimethalin @ 0.75 kg ha^{-1} (PE)	8.6 (72.9)	10.1 (103.5)	9.8 (97.4)	8.8 (77.1)	3.1 (9.6)	6.5 (41.9)	9.6 (91.8)	10.8 (116.0)
Pretilachlor @ 0.5 kg ha^{-1} (PE)	8.9 (76.8)	10.7 (115)	10.3 (106.4)	9.4 (87.2)	3.4 (11.2)	7.3 (52.3)	10.1 (105.8)	11.4 (128.4)
Manual weeding (20 and 40 DAS)	6.5 (38.9)	7.1 (48.5)	7.4 (55.1)	7.1 (49.4)	2.4 (5.6)	5.2 (26.6)	7.5 (56.3)	8.9 (79.3)
Twin wheel hoe at 20 DAS *fb* hand weeding at 40 DAS	5.8 (32.6)	6.8 (47.3)	7.1 (49.9)	6.8 (44.6)	2.2 (4.8)	4.8 (22.2)	7.2 (50.8)	8.5 (73.6)
SEm±	1.47	1.72	1.70	1.60	0.84	1.25	1.62	1.85
CD (P=0.05)	2.6	3.0	2.9	2.6	1.2	2.0	2.8	3.2
Fertility levels								
100% RDF	6.9 (44.6)	8.2 (67.2)	8.2 (67.2)	7.3 (55.1)	2.6 (6.42)	5.6 (30.9)	8.1 (65.6)	9.7 (94.7)
75% RDF + 5 tonnes FYM ha^{-1}	6.5 (41.5)	7.7 (59.7)	7.8 (58.9)	7.0 (49.0)	2.4 (5.5)	5.2 (26.1)	7.5 (55.8)	8.8 (76.5)
50% RDF + 10 tonnes FYM ha^{-1}	6.2 (37.5)	7.4 (55.3)	7.4 (55.2)	6.6 (44.1)	2.2 (4.5)	4.6 (20.4)	7.2 (51.4)	8.3 (68.4)
Without fertilizer + without FYM	9.8 (97.7)	11.6 (134.2)	11.2 (126.4)	10.5 (117.0)	3.9 (14.5)	8.1 (65.5)	11.3 (126.9)	12.5 (158.9)
SEm±	1.47	1.74	1.72	1.65	0.86	1.25	1.62	1.85
CD (P=0.05)	2.6	3.2	2.9	2.8	1.1	2.0	2.8	3.2

(The values in parenthesis are subjected to square root transformation).

Table 5: Effect of different weed management practices and fertility levels on economics of groundnut (Pooled data for 2020 and 2021).

Treatments	Cost of cultivation Rs. ha^{-1}	Gross return Rs. ha^{-1}	Net return Rs. ha^{-1}	B:C
Weed management practices				
Pendimethalin @ 0.75 kg ha^{-1} (PE)	48956	71291	22335	1.5
Pretilachlor @ 0.5 kg ha^{-1} (PE)	48456	74061	25605	1.5
Manual weeding (20 and 40 DAS)	56881	90442	33561	1.6
Twin wheel hoe at 20 DAS *fb* hand weeding at 40 DAS	55381	92588	37207	1.7
SEm±	1497.65	2268.42	1023.40	0.03
CD (P=0.05)	5241.8	8204.9	3274.9	0.1
Fertility levels				
100% RDF	47350	71028	23678	1.5
75% RDF + 5 tonnes FYM ha^{-1}	55675	87037	31362	1.6
50% RDF + 10 tonnes FYM ha^{-1}	58800	99961	41161	1.7
Without fertilizer + without FYM	45130	54156	9026	1.3
SEm±	1497.65	2347.42	1013.40	0.03
CD (P=0.05)	5241.8	8347.9	3274.9	0.1

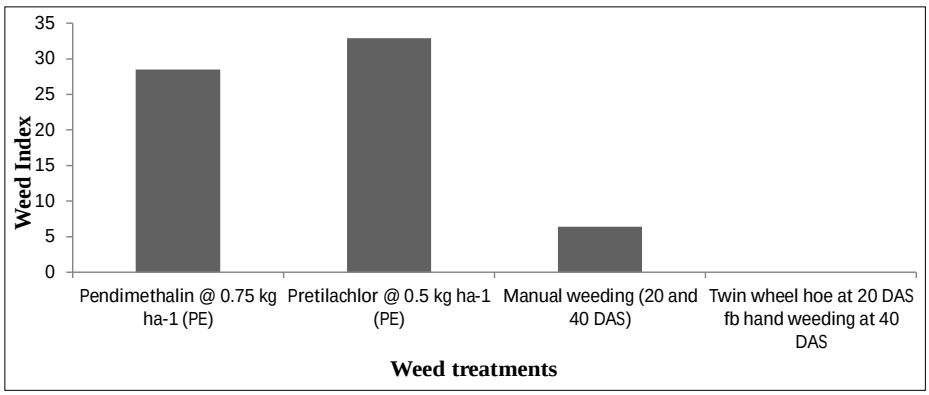

Fig 2: Weed Index in each herbicide treatment at various crop growth stages (Mean of 2 years).

Vala *et al*., 2017). The application of crop nutrients through fertilizers and FYM in an appropriate quantity and proportion ensured the availability of nutrients over an extended period in sufficient amounts, resulting in higher photosynthetic activity, better accumulation of photosynthates and its subsequent conversion to yield. The results are in corroboration with the findings of (Irungbam *et al*., 2016).

Application of 50% RDF + 10 tonnes FYM ha^{-1} reported better weed control efficiency. This treatment effectively prevented the weed growth and provided better environment for crop growth. These results are in close conformity with the findings of (Dhanapal *et al*., 2015). This treatment was also economic and gave higher B:C. This might be due to increase in pod yield, haulm yield and shelling percentage. These results are in conformity with the findings of (Gunri *et al*., 2015).

CONCLUSION

Based on field experimentation, it can be concluded that groundnut under weed management with twin wheel hoe at 20 DAS followed by hand weeding at 40 DAS along with application of 50% RDF + 10 tonnes FYM ha^{-1} was the most effective strategy for controlling the weed menace in groundnut with the highest weed control efficiency.

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Conflict of interest

The authors declare that they have no conflict of interest.

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