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Effect of pre emergence herbicides on physiological parameters and yield of groundnut (*Arachis hypogaea* L.)

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Abstract
To study the effect of different pre-emergence herbicides on physiological growth parameters of groundnut (*Arachis hypogaea* L.) a field trial was conducted at Central farm, OUA & T, Bhubaneswar during Rabi 2014-15. This experiment was operated with five treatments such as weedy check (control), butachlor, alachlor, oxyfluorfen and weed free check (hand weeding) with three replications under Randomize Block Design (RBD). Our studied revealed that among all pre-emergence herbicides application of butachlor (50% EC) @ 1000ml ha^{-1} effectively controls weed population and recorded the highest values of growth. In contrast to this, application of alachlor adversely affected and noted the lowest value of growth. The physiological growth parameters such as LAI, SLA, SLW, LAR, RGR, NAR and CGR significantly responded to herbicides application over the weedy check (control). All the above mentioned physiological parameters are highly correlated with pod yield of groundnut.

Keywords: groundnut, herbicides, LAI, SLW, RGR, NAR, CGR, pod yield

Introduction
Groundnut is considered to be an important oil seed crop and it is growing in different regions of the world. Groundnut oil is used as edible oil, kernels can be consumed directly as raw, roasted or boiled. Groundnut cake also used as animal feed, industrial raw materials and haulms can be used as food for livestock. These multiple uses of groundnut plant make it an excellent cash crop [1]. Groundnut production is influenced by several environmental factors such as solar radiation, temperature, humidity, rain fall and nutrient availability [2]. It belongs to leguminous family but growing pattern is differing from legume plant by forming peg, so called unpredictable legume.

In groundnut, accumulation of dry matter increased significantly with the age of crop. Dry matter increases progressively up to harvest of groundnut [3]. Specific Leaf Area (SLA) and Specific Leaf Weight (SLW) are reciprocal in nature and determine the thickness of leaf. High SLA species showed high rates of CO_2 uptake per unit leaf and root mass and a high rate of photosynthesis per unit leaf [4]. Crop with high SLW (thick leaves) had leaves with a small surface area to volume ratio, which is considered to be an advantage in using water efficiently [5]. Leaf area index (LAI) is used to determine rate of photosynthesis, evapo-transpiration and a reference tool for crop growth. LAI plays significant role in interception of light, radiation-use efficiency (RUE) and plant growth [6]. The sharper increase of LAI between 45 DAS to 60 DAS pointed out a period of rapid physiological development. Groundnut growth in the absence of weeds attains maximum LAI [7]. Weed free crops show higher Relative Growth Rate (RGR) than crops associated with weeds [8]. In groundnut, after a certain stage of crop growth, Net Assimilation Rate (NAR) decreases up to physiological maturity due to mutual shading of leaves which limits the rate of photosynthesis [2]. Weed control methods significantly affect Crop growth rate (CGR) [8]. CGR in groundnut attains its peak in between 60-75DAS and decrease afterwards restricting the photosynthesis rate [9]. Higher level of LAI and NAR results higher CGR [10]. Runner cultivars of groundnut have higher pod number and yield than bunch type due to higher CGR in former [11].

Weeds are major problems for groundnut production. They compete with groundnut for resources acquisition and interference with pegging, pod development and dry matter accumulation of groundnut [12]. Therefore weed management is necessary for proper physiological growth and development of the crop. Weeds can be controlled efficiently by using herbicides, but previous worker have viewed that, herbicides adversely affect the physiology of plant growth, dry matter accumulation and yield performance of groundnut. When herbicides applied frequently, it may accumulated in the soil and at elevated level impaired with the metabolic activities resulting in reduced growth of rhizobia, legumes or both. Herbicide (metribuzin) inhibiting photosynthesis affects *Rhizobium* sp [13], plant [14] and

The legume –*Rhizobium* symbiosis [15].
Retrieving the above mentioned facts, this present investigation was used to study detailed about growth parameters in groundnut influenced by herbicides treatment.

Materials and Methods

Experimental Site

The present set of experiments were conducted at central farm, Orissa University of Agriculture &Technology, Bhubaneswar at (85^0 52' E longitude and 20^0 15'N latitude with an elevation of 25.5 meters above mean sea level) during 2014-2015.

Soil Characteristics

The soil was classified as well drained, sandy loam and slightly acidic in nature (pH 5.4). Composite soil samples were collected from the experimental site from a depth of 15cm before sowing and were analysed for important physic-chemical characters. Analysis of soil revealed that sand, slit and clay found 75.4%, 13.4% and 11.2% respectively. Soil was characterized- by low organic carbon (0.38%), particle density (2.67g.cm^{-3}), bulk density (1.56gcm^{-3}) available of P (15.4 kgha^{-1}) and K (156.8 kgha^{-1}).

Description of the variety

Groundnut variety used for the present investigation was Devi, and moderate pod size having 2-3 seeds. Maturation duration of this variety was 110-115 days from the date of sowing.

Treatments

These experiments were carried out with five treatments, such as, T_0- Weed check (Control),T_1–Butachlor 50% EC) @ 1000ml/ha, with two hand weeding at 21 & 40 DAS,T_2- Alachlor (50% EC) @ 800 ml/ha, with two hand weeding at 21 & 40 DAS, T_3- Oxyfluorfen (23.5%EC) @ 80 ml/ha, with two hand weeding at 21 & 40 DAS, T_4- Weed free check (Manual weeding).

Application of manures and fertilizer

One fully loaded cart of FYM was applied to the soil uniformly before 3rdploughing. Basal dose of N:P:K @ 20:40:40 Kg/ha in the form of urea, single super phosphate and murate of potash respectively, were applied to plots prior to sowing.

Seed treatment and sowing of seeds

The groundnut seeds (var. Devi) were inoculated with Rhizobium culture before sowing @ 200g per 10 Kg kernels and were sown in lines after the treatment. The lines were drawn 25 centimetres apart by trench hoe and seeds were sown in furrows at equal depth maintaining a spacing of 10cm.

Herbicide Application

Two days after sowing, proper dose of pre-emergence herbicide mixed well with required quantity of water and allow it to stand for 5-10 minutes. Then it was sprayed with the help of a high volume knapsack sprayer. The spraying of herbicide was uniformly as blanket spray over the soil at evening hours.

Methods of data collection

Leaf area per plant

The Leaf area per plant was measured by using Leaf Area Meter. Five plants were selected randomly from different corner of a treated plot. Plants were cut at the soil surface leaves were separated from the plants by covering it in polythene bags and were brought to the laboratory. Leaf area of each plant was measured immediately and mean of these were considered as a leaf area of the plant.

Dry Matter

Five plants were uprooted randomly from different site of a treated plot. Root portion, Shoot parts and pods of all five plants separated and washed properly, dried at 65 ^{0}C in hot air oven for 48 hrs. After drying weighed it separately then total biomass of a plant was calculated. Observation of this parameter were recorded at 30, 45, 60, 90 DAS and also at harvest.

Pod Yield

To avoid border effect, one row on both sides of the length and 20cm border from breath side of the gross plot were not taken into consideration. The pod yield from individual net plots was recorded in kg after 3 consecutive sun drying from this observation the yield per hectare was computed in quintal per hectare.

Physiological growth parameters

Leaf area index (LAI)

LAI is expressed as the ratio of total leaf area (only one side) $plant^{-1}(cm^2)$ to the ground area (cm^2) occupied by the plant [16].

Specific leaf area (SLA)

SLA is the ratio of leaf areas (A) and leaf dry weight (W_L) [17].

$SLA = A / W_L$

Specific leaf weight (SLW)

SLW is the ratio of leaf dry weight (W_L) and leaf area (A)
$SLW = W_L / A$

Leaf area ratio (LAR)

LAR is defined as the ratio of leaf area (A) and total plant dry weight (W) [18].
LAR = A/W

Relative growth rate (RGR)

RGR was estimated with following formula [19].

$$RGR = \frac{In\,W_2 - In\,W_1}{t_2 - t_1}$$

Where, W_1 and W_2 are Total dry weight of plant at time t_1 and at time t_2, t_2- t_1 - Time interval in days

Net assimilation rate (NAR)

Net assimilation rate is the rate of increase in whole plant dry weight per unit time per unit area [19].

$$NAR = \frac{W_2 - W_1}{t_2 - t_1}, \frac{\ln A_2 - \ln A_1}{A_2 - A_1}$$

Where W_1 and W_2 were Dry weight of the community of plant at the start of the test period and at the end of the test period respectively, A_1 and A_2 were Total leaf Area of the community of plant at the start of the test period and at the end of the start period at time t_1 and t_2.

Crop growth rate (CGR)

Crop growth rate (CGR) represents the increase in dry weight of crop per unit area per unit time [19].

$$CGR = \frac{W_2 - W_1}{t_2 - t_1}$$

Where W_1 and W_2 were initial and final dry matter weight per unit area (g m^{-2}) at t_1 and t_2 periods, respectively and express as $gm^{-2}day^{-1}$.

Statistical analysis

The experimental design was simple Randomized Block Design (RBD). The obtained data were subjected to statistically analysed by ANOVA.

Results and Discussion

Leaf Area

Data presented in Table-1 revealed that leaf area was increased due to the application of pre-emergence herbicides. Leaf area observation taken at 30, 45, 60 and 90 DAS indicated that the leaf area was increased from 30 to 60 DAS, but after that there was declined in leaf area. At 30 DAS the maximum leaf area per plant was noted from weed free plot (1120.16 cm^2) followed by Butachlor treated plot (1021.96 cm^2), and the minimum value of the same was exhibited by control plot (773.73 cm^2). At 60DAS the highest leaf area (1970.10 cm^2) was contributed by weed free check, followed by Butachlor (1831.13 cm^2). At 90 DAS there was declined in Leaf area as compared to 60DAS. The highest leaf area (1470.37 cm^2) and minimum leaf area (878.13 cm^2) were observed in weed free check and weedy check, at 90 DAS respectively.

Table 1: Effect of pre-emergence herbicides on the leaf area (cm^2) per plant of groundnut var. Devi

Treatments		30DAS	45DAS	60DAS	90DAS
T_0	Weedy check	773.73	1003.26	1414.67	878.13
T_1	Butachlor	1021.96	1485.06	1831.13	1185.27
T_2	Alachlor	880.60	1227.40	1437.00	986.53
T_3	Oxyfluorfen	930.73	1438.67	1820.57	1072.63
T_4	Weed free check	1120.16	1576.30	1970.10	1470.37
	CD 5%	86.89	130.59	172.08	388.19

Increased in leaf area from 30DAS to 60DAS, then decreasing order is seen in 60DAS to 90 DAS in all the treatments. But higher leaf area was observed in all the stages of growth by weed free check and lowest value of the same was found in weedy check among the all treatments. Among the herbicide treatments, the highest leaf area was found in butachlor treatment and lowest value was observed in alachlor treatment. Higher leaf area was might be due to proper allocation of resources for growth of leaves by weed free check and butachlor treatment, preventing weeds and their competition with crop for resources. In weedy check, weeds efficiently compete for light, water and nutrient causes reduced in leaves growth. Alachlor might have reduced cell division and enlargement, due to phytotoxic effect which ultimately results into reducing the leaf area.

Dry matter

Variation in total biomass at different stages of growth due to the pre-emergence application of herbicide was presented in Table-2, which indicated that the maximum biomass production was exhibited by weed free check (4.00gm/plant) followed by Butachlor treatment (3.96 gm/plant) where as the minimum or lowest value of the same was shown in weedy check (2.72 gm/plant) at 30 DAS. At 90DAS the maximum biomass (45.90 gm/plant) was recorded from weed free check followed by Butachlor treatment (43.29 gm/plant), where the lowest value was exhibited by control (30.98 gm/plant).

Table 2: Effect of pre-emergence herbicides on the total biomass of the plant of groundnut var. Devi

Treatments		30DAS	45DAS	60DAS	90DAS	At harvest
T_0	Weedy check	2.72	5.53	14.34	30.98	32.25
T_1	Butachlor	3.96	7.44	19.37	43.29	44.56
T_2	Alachlor	3.33	6.17	15.08	35.18	37.43
T_3	Oxyfluorfen	3.48	6.79	17.26	38.15	39.03
T_4	Weed free check	4.00	7.53	19.70	45.90	46.66
	CD 5%	0.10	0.61	0.83	1.22	0.86

Total biomass accumulation or dry matter production followed the trend of leaf area development up to 60 DAS, this might be due to higher leaf area development. Higher leaf area intercept proper amount of light, which leads to higher dry matter accumulation. Our results agreed with findings of previous workers [20, 21]. Again from 60 to 90 DAS biomass accumulation increased at a constant rate, it might be due to plant attained physiological maturity and transfer solutes from source to sink.

Leaf Area Index (LAI)

Leaf Area index (LAI) recorded on different stages of growth i.e.30, 45, 60 and 90 DAS is presented in Table-3. The leaf area tended to increase with number of days increased. At 30 DAS the maximum LAI (4.48), was recorded from weed free check, followed by Butachlor treatment (4.09), and the lowest value of the same (3.10) was exhibited by weedy check. Similarly the maximum LAI, 6.30 and 7.88 were recorded from weed free plots at 45 and 60 DAS. Thereafter at 90DAS there was decreased in LAI and maximum LAI (5.21) was exhibited by weed free check followed by Butachlor (4.74) and the minimum value (3.94) was recorded from weedy check. Significant difference between the treatments was recorded in all stages of growth.

Table 3: Effect of pre-emergence herbicides on leaf area index (LAI) of groundnut var. Devi

Treatments		30 DAS	45 DAS	60 DAS	90 DAS
T_0	Weedy check	3.10	4.01	5.66	3.94
T_1	Butachlor	4.09	5.94	6.28	4.74
T_2	Alachlor	3.52	4.91	5.75	4.28
T_3	Oxyfluorfen	3.72	5.75	6.33	4.29
T_4	Weed free check	4.48	6.30	6.88	5.21
	CD 5%	0.359	0522	0.691	0.554

Application of herbicides as pre-emergence plays tremendous role in determining the Leaf Area Index (LAI) of crop, which is closely related to the photosynthesis. Due to control of weeds from the initial stages of the growth, nutrients and other inputs are properly utilized by the plant as a result of which emergence of leaves were faster in weed free check and herbicides treatments as compared to control. In weed free, the cell division was vigorous and there was no competition of weeds so leaves expand more easily. Larger leaf area permits higher rate of transpiration and also facilitate more carbon dioxide assimilation and interception of solar radiation, which are directly related to dry matter synthesis [22]. Application of herbicide may inhibit the cell division, which subsequently impair on leaf expansion. Simillar conclusions have been reported from previous worker [7].

Specific Leaf Area (SLA)

Comparison between SLA at different stage of growth indicated that there was decreasing trend of SLA from 30 DAS to 90 DAS, irrespective of treatments. At 30 DAS, maximum SLA was recorded from weed free check (284. 11 cm^2/gm) followed by Butachlor treatment (279.95 cm^2/gm) and the lowest value was recorded from weedy check (257.53cm^2/g) (Table 4). Similar trend were recorded in all the treatments at 45, 60 and 90 DAS.

Table 4: Effect of pre-emergence herbicides on specific leaf area (SLA) of groundnut var. Devi

Treatments		Days after sowing			
		30	45	60	90
T_0	Weedy check	257.53	182.14	94.04	24.98
T_1	Butachlor	279.95	199.94	98.70	31.85
T_2	Alachlor	264.67	199.07	95.32	25.83
T_3	Oxyfluorfen	258.30	212.22	100.02	28.31
T_4	Weed free check	284.11	223.60	113.02	33.80
	CD 5%	20.366	24.734	9.272	4.169

4.3.3 Specific Leaf Weight (SLW)

The SLW of the groundnut at different stages of growth due to effect of pre-emergence herbicide application were recorded and presented in Table-5. The maximum SLW was recorded in weed free check, where as the lowest value of the same was recorded from weedy check at every stages of crop growth. At 30 DAS weed free check recorded the highest value (3.88 mg/cm^2) followed by Butachlor treated plot (3.87 mg/cm^2) and lowest value of the same was recorded from control plot (3.50 mg/cm^2). At 45, 60 and 90 DAS the maximum value of SLW 5.52 mg/cm^2, 10.65mg/cm^2 and 40.20 mg/cm^2 were recorded from weed free plots respectively. Significant difference between the treatments was observed with respect to SLW.

Table 5: Effect of pre-emergence herbicides on specific leaf weight (SLW) of groundnut var. Devi

Treatments		30 DAS	45 DAS	60 DAS	90 DAS
T_0	Weedy check	3.50	4.73	9.49	31.42
T_1	Butachlor	3.87	5.47	10.50	38.78
T_2	Alachlor	3.78	5.02	10.00	35.01
T_3	Oxyfluorfen	3.53	5.02	10.14	35.59
T_4	Weed free check	3.88	5.52	10.65	40.20
	CD 5%	0.262	0.642	1.376	4.027

Specific leaf area (SLA) and specific leaf weight (SLW) are reciprocal in nature and are used to determine the leaf thickness [23]. Generally leaves with lower SLA and/or higher SLW are thicker, and thickness of leaves governing significant role in plant survival and metabolism. Indirect measurement of leaf water relation relationship, photosynthetic capacity and growth potential would be done through SLA [24]. Thickness of leaves favours acquisition and use of resources (Vile *et al*., 2005) which ultimately contribute towards the yield capacity of a crop [17]. Thicker leaf contains higher chlorophyll density per unit area as a result of which photosynthetic capacities was higher than thin leaf [25, 26].

Leaf area ratio (LAR)

The LAR recorded at 30-45 DAS, 45-60 DAS and 60-90 DAS due to the effect of pre –emergence application of herbicide were presented in Table-6. Data presented in Table indicated that there was a decreasing rate of LAR from initial to final stages of growth irrespective of treatments. At 60-90 DAS maximum LAR was recorded from weed free check (54.98 cm^2/g) followed by Butachlor (53.68 cm^2 /g).

Table 6: Effect of pre-emergence herbicides on leaf area ratio (LAR) of groundnut var. Devi

Treatments		Days after sowing		
		30-45 DAS	45-60 DAS	60-90DAS
T_0	Control	223.37	129.57	49.86
T_1	Butachlor	224.72	132.48	53.68
T_2	Alachlor	226.97	136.73	47.82
T_3	Oxyfluorfen	239.25	144.67	51.56
T_4	Weed free	249.25	139.54	54.98
	CD 5%	17.53	8.72	3.23

Leaf area ratio (LAR) is morphological index of plant (leaf area per unit dry weight of plant) which is closely connected with the photosynthetic activity of leaves [27]. In other words leaf area ratio (LAR) indicates the size of assimilatory surface area in relation to total dry matter accumulation. The leaf area was increased up to 60 DAS then decreased towards the maturity. Among the treatment higher LAR was recorded in weed free check (249.25cm^2 /g) and lowest was noticed in

weedy check (223.37cm² /g) at 30-45 DAS. At 30-45 DAS the increased LAR indicates that there is tendency to produce more leaf area per unit dry matter for better light interception. Among the herbicides oxyfluorfen recorded the highest LAR (239.25 37cm² /g) at 30-45 DAS (Table-6).The present findings agreed with the reports of previous worker [28].

Relative Growth Rate (RGR)

Comparison between the Relative Growth Rate (RGR) at different stages of growth due to the pre –emergence application of herbicides was reflected in Table-7 which revealed that RGR in all the treatments increased up to 60 DAS and there after decreased in a greater extend. At 30-45 DAS and 45-60 DAS maximum RGR were recorded from weed free check was 47.37 mg/day and 64.21 mg/day respectively, where the minimum value of the same were estimated from weedy check (41.18 mg/day and 56.93 mg/day). At 90DAS the maximum RGR recorded from weed free check (28.23 mg/day). These findings were corroborating with the results of previous workers [8, 2].

Table 7: Effect of pre-emergence herbicides on relative growth rate (RGR) of groundnut var. Devi

Treatments		30-45 DAS	45-60 DAS	60-90DAS
T_0	Weedy check	41.18	56.93	25.69
T_1	Butachlor	44.54	63.80	28.19
T_2	Alachlor	42.08	61.31	26.48
T_3	Oxyfluorfen	43.80	62.21	26.80
T_4	Weed free check	47.37	64.21	28.23
	CD 5%	2.968	4.74	1.809

The possible reasons for decreased in RGR after 60 DAS might be increased in root and stem (non-photosynthetic biomass), shadings of lower leaves by top leaves of plant and limiting of soil nutrient [29].

Net assimilation rate (NAR)

The NAR recorded at 30-45 DAS, 45-60 DAS and60- 90 DAS was presented in Table-18, which indicated that there was increasing NAR in all stages of growth. At 30-45 DAS, the maximum NAR (0.18 mg/cm^2/day) was observed from weed free check and at 45-60 DAS (0.51 mg/cm^2/day) and 60-90 DAS (0.59 mg/cm^2/day) respectively. The lowest value of NAR was exhibited by weedy check were 0.18 mg/cm^2/day, 0.45 mg/cm^2/day and 0.57 mg/cm^2/day at 30-45,45-60 and 60-90 DAS respectively (Table-8).

Table 8: Effect of pre-emergence herbicides on net assimilation rate (NAR) (mg/cm^2/day) of groundnut var. Devi

Treatments		30-45 DAS	45-60 DAS	60-90DAS
T_0	Weedy check	0.18	0.45	0.47
T_1	Butachlor	0.19	0.48	0.57
T_2	Alachlor	0.18	0.45	0.49
T_3	Oxyfluorfen	0.19	0.46	0.49
T_4	Weed free check	0.25	0.51	0.59
	CD 5%	0.04	0.04	0.05

NAR activity in weed free check and treated herbicide treatments was found higher due to more leaf and less weed population compared to weedy check. Greater NAR in herbicide treatments indicates higher rate of photosynthesis. The present findings are in conformity with the results obtained by previos workers, where they indicated that NAR was significantly increased up to 90 DAP when light treatment was given but disagreed to our findings when boron treatment was given to groundnut results into leaves area increased which causes shading of older leaves by the new leaves hence decreased in NAR [30].

Crop Growth Rate (CGR)

Data reflected in Table-9 revealed that CGR estimation at 30-45, 45-60 and 60-90 DAS were in increasing rate. The maximum CGR at 45-60 DAS was contributed by weed free check (3.247 gm/m^2/day) followed by Butachlor (3.183 gm/m^2/day) where the minimum value of the same was exhibited from weedy check (2.217 gm/m^2/day). At 60-90 DAS the maximum CGR (3.49 gm/m^2/day) was observed from weed free check. Similar trend was registered for Crop growth rate was maximum in between 61-75 DAS irrespective of treatments [31].

Table 9: Effect of pre-emergence herbicides on crop growth rate (CGR) (g/m^2/plant/day) of groundnut var. Devi

Treatments		30-45 DAS	45-60 DAS	60-90DAS
T_0	Control	0.75	2.22	2.35
T_1	Butachlor	0.93	3.18	3.19
T_2	Alachlor	0.76	2.38	2.68
T_3	Oxyfluorfen	0.88	2.78	2.78
T_4	Weed free	0.97	3.25	3.49
	CD 5%	0.14	0.32	0.18

Pod Yield

Pod yield was estimated in quintal per hectare. Use of herbicides in crop can potentially affects the pod yield. Data presented in Fig.1 represents the highest pod yield in weed free check (13.92 q/ha) and the lowest value (11 q/ha) in weedy check. Among the herbicide treatments butachlor treatment estimated the higher pod yield (81.28 q/ha) followed by oxyfluorfen treatment (11.75 q/ha). Our findings supported the opinion for pod yield is attributed to higher dry matter accumulation and CGR [11]. In this study, pod yield was positively correlated with all the growth parameters (0.88-0.98) calculated.

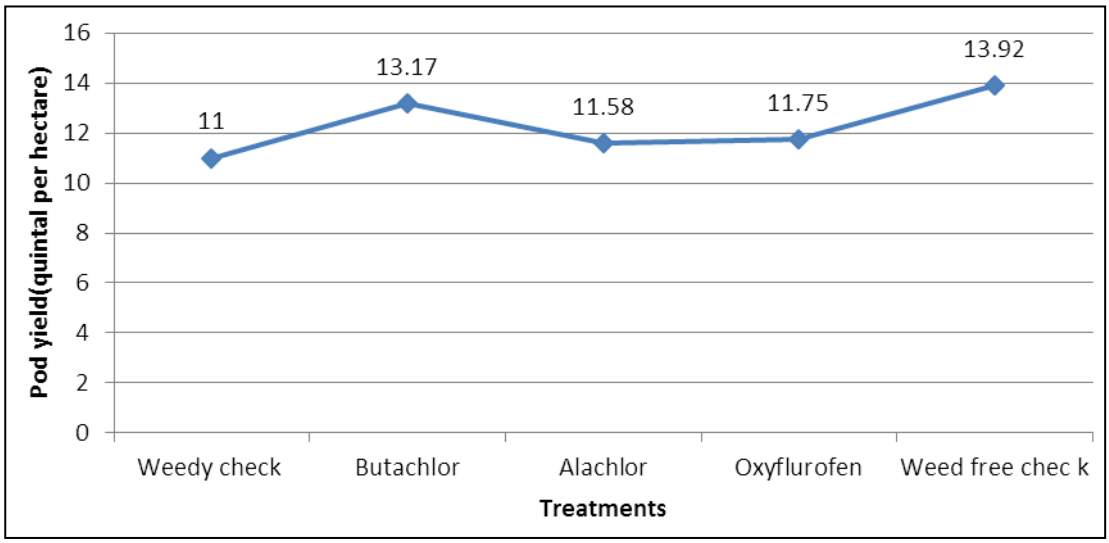

Fig 1: Showing pod yield per hectare due to effect of pre-emergence herbicides on groundnut var. Devi.

In conclusion, weed free check estimated as higher pod yield as compared to other treatments. Butachlor (50% EC) @ 1000ml/ha, with two hand weeding at 21 & 40 DAS had higher yield when compared with other herbicide treatSSSSSments. The increment in pod yield in these treatments could be assigned to its positive influence on LAI, SLW, RGR NAR, and CGR.

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