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GROWTH AND YIELD OF GROUNDNUT (*ARACHIS HYPOGAEA* L.) AS INFLUENCED BY WEED MANAGEMENT PRACTICES AND *RHIZOBIUM* INOCULATION

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ABSTRACT

Groundnut (*Arachis hypogaea* L.) productivity in India is low, because of many problems beset in its cultivation. One of the serious problems are weeds. Groundnut yield losses due to weeds have been estimated as high as 24 to 70 percent. This has created a scope for using herbicides in groundnut crop.
A field investigation was carried out during *kharif* (rainy) season of 2001-2002 on a sandy loam soil at College Agronomy Farm, B.A. College of Agriculture, Gujarat Agricultural University, Anand, India to study the effect of weed management practices and *Rhizobium* inoculation on growth and yield of groundnut (*Arachis hypogaea* L.). Ten weed control treatments, comprising four treatments of sole application of fluchloralin, pendimethalin, butachlor and metolachlor, respectively each applied at 1.0 kg ha^{-1}; four treatments comprising of an application of the same herbicides at the same levels coupled with one hand weeding at 30 DAS; one weed-free treatment (hand weedings at 15, 30, 45 DAS); and one unweeded control. All 10 treatmets were combined with and without *Rhizobium* inoculation (i.e. a total of 20 treatment combinations) under a factorial randomized complete block design (FRBD) with four replications.

Minimum weed dry matter accumulation (70 kg/ha) with higher weed control efficiency (90.70 %) was recorded under an integrated method i.e. pendimethalin at 1.0 kg ha^{-1} + hand weeding at 30 DAS, which also resulted in maximum pod yield (1773.50 kg ha^{-1}). This treatment was comparable to fluchloralin applied at 1.0 kg ha^{-1} combined with hand- weeding at 30 DAS. Weedy conditions in the unweeded control treatment reduced pod yield by 29.90-35.95 % as compared to integrated method. Significantly higher pod yield was obtained with *Rhizobium* inoculation than the mean value of all treatments without inoculation. For most agronomical parameters examined, *Rhizobium* inoculation and weed control treatments were independent in their effect.

INTRODUCTION

Groundnut, the kingpin among oilseed crops in India, alone occupies about 9.0 million hectares of land (45% of total oil seed area) and accounts for 8.2 million tonnes of oil seeds (55% of total Indian oil seed production) both of which are claimed to be world's largest figures obtained in any country. Paradoxically, India is one of the largest importers of edible oil because total production does not meet local demand. As groundnut is predominantly grown as rainfed crop under various biotic and abiotic stresses, yields are low. However, it is quite important in India both for local use and as a foreign exchange earner in the form of hand-picked selection (Hps) kernels and deoiled cakes. Groundnut is mainly grown during the rainy season. Therefore it encounters several weeds since annual grasses and seasonal broad-leaf weeds grow more luxuriantly and dominate during this season as compared to *Rabi* (winter)/the drier (summer) season. Weed competition in early stages of groundnut crop development is maximum because of slow initial foliage growth limited by the degradation of food reserves in the cotyledons. Although emergence of radicle in groundnut is fast (24-48 h), definitive root development is slow (5-10 days). Only when roots are capable of absorbing nutrients, the epicotyl is exposed to light in groundnut, whereas the situation is opposite in the case of weeds which emerge faster and grow more rapidly as compared to groundnut and consequently take a lead in crop - weed competition. The critical period of weed competition is estimated to lie within 2 to 6 weeks after sowing. Minimizing crop-weed competition particularly at early stages of growth, the yield could be improved by about 20-30% (Yaduraju, 1980 and Patel *et al.*, 1997).

With ever-increasing costs of nitrogenous fertilizers, greater emphasis has gone to the use of alternative and renewable sources of nitrogen. Biological nitrogen fixation through micro-organisms as bio-fertilizers is a cheap and supplementary source of nitrogen. Certain micro-organisms present in the soil have the ability to convert atmospheric N_2 into ammonia (N fixation) which is readily absorbed by plants. *Rhizobium*, is a root nodule bacterium that engages in a mutually beneficial association (symbiosis) with legumes and fixes nitrogen. Groundnut, being a leguminous crop can fix atmospheric nitrogen through its symbiosis with *Rhizobium*. *Rhizobium* inoculation has been shown to increas pod yield in groundnut (Patel and Thakur, 1997 and Samui, 1997). By keeping the above points in mind, the present investigation was conducted to study both independent and interaction effects of a number of weed management practices and *Rhizobium* inoculation in groundnut.

MATERIALS AND METHODS

A field experiment was conducted at College Agronomy Farm, B.A. College of Agriculture, Gujarat Agricultural University, Anand, India during *kharif* (rainy) season of the year 2001-2002. The soil was sandy loam in texture, low in nitrogen (Kjeldhal method), medium in phosphorus (Olsen method) and high in potassium (Kjeldhal method). The study was carried out with a view to find out the efficacy of various pre-emergence herbicides for weed control in bunch type variety (GG-2) of groundnut (*Arachis hypogaea* L.). Ten weed control treatments comprising four treatments (W_1 to W_4) of sole application of pre-emergence herbicides fluchloralin, pendimethalin, butachlor and metolachlor, respectively, each applied at 1.0 kg ha^{-1}; four applications (W_5 to W_8) of the same herbicides at the same levels combined with one hand weeding at 30 DAS; one weed free treatment (W_9: hand weedings at 15, 30, 45 DAS) and one unweeded control (W_{10}). All 10 treatmets were combined with (R_1) and without (R_0) *Rhizobium* inoculation (yielding a total of 20 treatment combinations) under a factorial randomized complete block design (FRBD) with four replications.

For treating 100 kg seeds of groundnut, a solution of 5% sugar was prepared in water. Two hundred grams of carrier-based *Rhizobium* culture was added to the sugar solution. Seeds were evenly spread on a cement floor/plythene sheets and slugar solution was poured and evenly smeared on the seeds surface. Groundnut seeds were subsequently inoculated through direct coating with *Rhizobium* (10^5 cells seed^{-1}). Seed inoculation was done 48 hours prior to sowing. Before coating with *Rhizobium*, seeds were moistened to allow *Rhizobium* culture to stick to the seeds. Herbicides were applied to the soil one day after sowing. Weed numbers were counted randomly by 0.25 m^2 quadrats from net plot areas at different three spots from each plot at 20, 40 DAS and at harvest and converted into number per m^2 area. Weed infestation was also assessed by measuring dry weight of seeds per plot at 20, 40 DAS and at harvest (Okugie and Ossom, 1988; Spandl *et al.*, 1999). Weed control efficiency was calculated by using formula suggested by Mani *et al.* (1973).

$$WCE = \frac{DWC - DWT}{DWC} \times 100$$

Where:
WCE = weed control efficiecy;
DWC = dry weight of weeds from control plots (weedy check); and
DWT = dry weight of weeds in treated plots.

Yield reduction (%) owing to the presence of weeds was estimated by using the formula developed by Gill and Kumar (1969) and expressed as weed index (WI):

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

Where:
WI = weed index (%);
X = yield fromweed free plot; and
Y = yield from the treatment for which weed index is to be estimated.

Harvest index is the ratio of economic yield to biological yield per plot. It was calculated by using the formula given by Donald and Hamblin (1976),

$$HI = \frac{\text{Economic yield (kg/ha)}}{\text{Above ground biological yield}} \times 100$$

Observation of number of nodules per plant was done at 45 and 60 DAS. Three groundnut plants from each net plot were randomly selected; plants were dug out with the help of kudali. Sufficient care was taken so that entire root system of the plant could be removed from soil without any injury to nodules. Plant root portions were kept in water to subsequently wash out soil particles. Thereafter, individual nodules were seperated from the roots and counted for each plot. Average number of nodules per plant was recorded treatment wise. Statistical analysis of the data of various characters studied in the investigation was carried out through the statistical analysis of variance techniques as described by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Weed Intensity (No. m^2) and Dry Weight (kg ha^{-1})

Data on weed population and dry weight of weeds recorded at 20, 40 DAS and at harvest revealed that both parameters (Table 1) were significantly influenced by different weed control treatments. In general, all weed control treatments considerably reduced total weed population and dry weight as compared to weedy check.

Table 1. Weed intensity (No m^2) and dry weight of weeds (kg ha^{-1}) as influenced by different weed control treatments and *Rhizobium* inoculation

Treatment	**Weed intensity (No m^2)**			Weed dry weight (kg ha^{-1})			WCE (%)
	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest	
Weed Control Treatments (W), Herbicides (kg ha^{-1})							
W_1: Fluchloralin at 1.0	11.45	24.45	39.25	51.50	93.00	127.75	83.03
W_2: Pendimethalin at 1.0	6.65	24.03	36.18	27.90	91.33	136.75	81.84
W_3: Butachlor at 1.0	18.50	30.75	50.43	79.85	115.00	198.90	73.59
W_4: Metolachlor at 1.0	17.72	30.50	44.95	57.75	117.70	167.55	77.75
W_5: Fluchloralin at 1.0 + HW	13.77	14.00	26.35	77.20	45.00	98.10	86.97
W_6: Pendimethalin at 1.0 + HW	9.87	10.60	19.95	44.97	27.50	70.00	90.70
W_7: Butachlor at 1.0 + HW	18.63	15.20	32.15	85.57	60.95	116.75	84.50
W_8: Metolachlor at 1.0 + HW	16.45	15.25	29.70	71.02	56.15	114.15	84.84
W_9: Weed Free	5.66	20.50	56.35	25.25	81.8	194.40	74.18
W_{10}: Weedy Check	234.43	235.50	264.28	597.50	513.5	753.00	-
S. Em. **±**	2.90	1.47	2.29	6.65	10.28	19.64	-
CD at 5 %	8.29	4.20	6.55	19.04	29.45	56.24	-
***Rhizobium* inoculation (R)**							
R_0: Without *Rhizobium*	34.82	43.30	58.91	115.63	126.59	200.24	73.41
R_1: With *Rhizobium*	35.81	40.46	61.01	107.24	113.80	195.23	74.07
S. Em. **±**	1.30	0.66	1.02	2.97	4.60	8.78	-
CD at 5 %	NS	NS	NS	NS	NS	NS	-
Interaction (W x R)	NS	NS	9.27	NS	NS	NS	-
C. V. %	20.09	8.58	9.35	14.61	20.96	24.33	-

HW = Hand weeding; DAS= Days after sowing; S.Em. = Standard error of mean; CD = Critical Difference; WCE = Weed control efficiency

Weed-free treatment (W_5) recorded minimum weed counts (5.66 m^2) and dry weight of weeds (25.25 kg ha^{-1}) at 20 DAS followed by application of pendimethalin at 1.0 kg ha^{-1} (W_2). Whereas pendimethalin at 1.0 kg ha^{-1} along with one hand weeding, markedly reduced weed population and dry weight of weeds at 40 DAS (10.60 m^2, 27.50 kg ha^{-1}, respectively) and at harvest (19.95 No. m^2, 70.00 kg ha^{-1}). This was statistically followed by treatment H_5. This might be due to the fact that at higher concentration of pendimethalin, germinating weed seeds might have been killed resulting into lower weed populations. In general, herbicides combined with one hand weeding were most effective in suppression of weeds in terms of density and dry matter accumulation as compared to sole applications of herbicides. This indicated that superimposition of hand weeding or herbicide treatment done at 30 DAS was beneficial for the control of later emerged weeds. These results are in agreement with the findings of Pandey and Padhiyar (2000) and Attrade *et al.* (2001) who stated that integrated weed management with pre-emergence application of pendimethalin at 1.0-1.5 kg ha^{-1} followed by one hand weeding at 30 DAS was found effective in controlling weeds in *kharif* (rainy) groundnut in India. Pre-emergence application of butachlor and metolachlor each at 1.0 kg ha^{-1} was found to be inferior to pendimethalin (W_2 & W_6, Table 1) but performed better as compared to unweeded control in checking weed dry matter accumulation.

Weed Control Efficiency (WCE)

Highest weed control efficiency (90.70 %) was recorded under pendimethalin applied at 1.0 kg ha^{-1} + HW 30 DAS, closely followed by fluchloralin at 1.0 kg ha^{-1} + HW (86.97 %). Appreciably lower weed counts and dry weight of weeds at harvest resulted from timely removal of all categories of weeds at early as well as later stages of crop growth by supplementing hand weeding at 30 DAS. This result corroborates the findings of Murthy *et al.* (1994) and Pandey and Padhiyar (2000). Interaction of weed control treatments and *Rhizobium* inoculation on weed intensity, dry weight of weeds and WCE were found to be non-significant. Jhala *et al.* (2005) reported that pendimethalin was superior in controlling weeds as compared to other herbicide treatments.

Root Nodule Counts (nodules/plant)

Mechanical treatments as well as herbicides combined with one hand weeding were effective with respect to higher number of root nodules per plant, i.e. 57.10 root nodules per plant at 60 DAS for treatment W_8 (Figure 1) against treatment W_{10}. This might be due to effective weed control whereas good physical condition of soil may also enhance micro-organism activity in soil. *Rhizobium* inoculation did show its significant influence. Higher number of root nodules were noticed with *Rhizobium* inoculation treatment as compared to without inoculation. Negre *et al.* (1991) and Patel and Patel (1989) have also reported the same effect of inoculation on groundnut root nodulation.

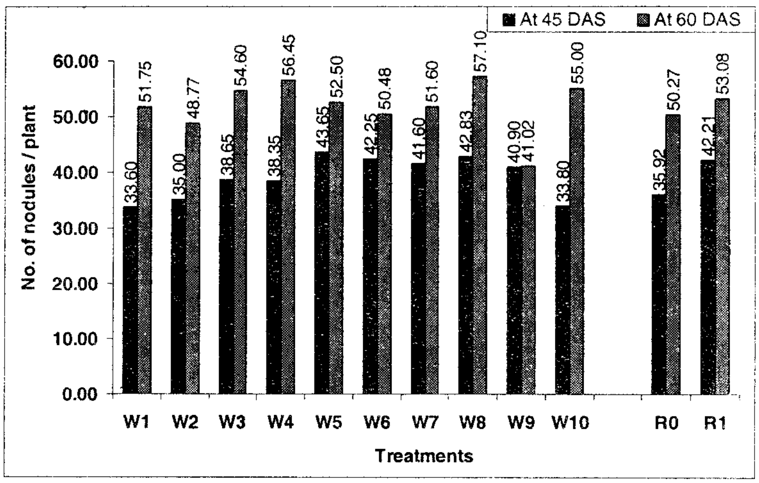

Figure 1. Number of root nodules per plant as influenced by weed management practices and *Rhizobium* inoculation (R0 = Without *Rhizobium* inoculation; R1=With inoculation).

Pod and Haulm Yields (kg ha^{-1})

Weed control treatments significantly influenced pod and haulm yields (Table 2.), wherein pendimethalin at 1.0 kg ha^{-1} supplemented with hand weeding (W_6) produced significantly higher pod and haulm yields of 1773.50 and 3012.50 kg ha^{-1}, respectively, both these values being statistically at par with treatment W_5 (1619.83 and 2946.00 kg ha^{-1}, respectively), W_2 (1590.50 and 2812.50 kg ha^{-1}), W_1 (1566.50 and 2807.00 kg ha^{-1}) and W_3 (1474.50 and 2744.00 kg ha^{-1}). Pod and haulm yields under these treatments were 35.95 % and 10.32 % higher than unweeded control and pendimethalin applied at 1.0 kg ha^{-1} alone, respectively. All other herbicides along with hand weeding were alike but significantly superior to unweeded control in respect to pod and haulm yields. This might be due to removal of later-emerged weeds by hand weeding at 30 DAS. Results further revealed that beneficial effect of loosening the soil by hand weeding, which appears to facilitate the entry of gynophores (needles or pegs) to proper depth in the soil and subsequent normal growth and development of pods. Unweeded control recorded lowest groundnut pod yield (1136.0 kg ha^{-1}) with 35.95% weed index (WI). This was probably due to strong crop-weed competition for growth factors such as moisture, nutrients and space (Jhala *et al.* 2005)

Table 2. Pod and haulm yields (kg ha^{-1}) as influenced by different weed control treatments and *Rhizobium* inoculation

Treatment	Yields (kg ha^{-1})		HI (%)	WI (%)
	Pod	Haulm Yield		
Weed Control Treatments (W), Herbicides (kg ha^{-1})				
W_1: Fluchloralin at 1.0	1566.50	2807.00	35.87	11.67
W_2: Pendimethalin at 1.0	1590.50	2812.50	35.11	10.32
W_3: Butachlor at 1.0	1474.50	2744.00	35.12	16.86
W_4: Metolachlor at 1.0	1411.50	2564.00	36.60	20.91
W_5: Fluchloralin at 1.0 + HW	1619.83	2946.00	35.72	8.66
W_6: Pendimethalin at 1.0 + HW	1773.50	3012.50	37.21	-
W_7: Butachlor at 1.0 + HW	1497.67	2716.33	35.59	15.55
W_8: Metolachlor at 1.0 + HW	1431.50	2650.00	35.11	19.28
W_9: Weed Free (HW at 15,30, 45 DAS)	1452.34	2679.50	35.18	18.11
W_{10}: Weedy Check	1136.00	2346.50	32.78	35.95
S. Em. ±	39.24	110.23	1.23	-
CD at 5 %	112.37	315.67	NS	-
***Rhizobium* inoculation (R)**				
R_0: Without *Rhizobium*	1464.10	2687.80	35.25	16.96
R_1: With *Rhizobium*	1526.60	2767.90	35.56	13.91
S. Em. ±	17.55	49.30	0.55	-
CD at 5 %	50.25	NS	NS	-
Interaction (W x R)	NS	NS	NS	-
C. V. %	6.41	9.90	8.49	-

HI = Harvest index; WI = Weed index

It was observed that significantly (4.09%) higher pod yield was obtained when seeds were inoculated with *Rhizobium* over without inoculation. This was relevant to the findings of Patel and Thakur (1997). The absence of interaction effects indicated that both weed control treatments and *Rhizobium* inoculation have an independent effect on the crop.

Data pertaining to harvest index (%) indicated that effect of different weed control treatments and *Rhizobium* inoculation, and interaction effects were not significant. However, the highest harvest index (HI) was recorded under treatment W_6 (37.21 %) followed by W_4 (36.60 %), whereas the lowest was obtained with weedy check treatment (32.78%) (Table 2).

CONCLUSION

Based on the results of our field experiment, minimum weed dry matter accumulation (70 kg ha^{-1}) with higher weed control efficiency (90.70 %) and harvest index (37.21) was recorded under an integrated method W_6 (i.e. pendimethalin at 1.0 kg ha^{-1} + hand weeding at 30 DAS), which also resulted in maximum pod and haulm yields (1773.50 and 3012.50 kg ha^{-1}, respectively). Higher yield was obtained with *Rhizobium* inoculation than without inoculation. Unweeded control recorded lowest groundnut pod yield (1136.0 kg ha^{-1}) with 35.95% weed index (WI) and harvest index (32.78%). Interaction effects of weed control treatments and *Rhizobium* inoculation on weed intensity, dry weight of weeds, WCE, pod and haulm yields were found to be non-significant.

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