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AGRO-PHYSIOLOGICAL ASSESSMENT OF WEED INTERFERENCE IN GROUNDNUT (*ARACHIS HYPOGEA* L.) AT SUB-HIMALAYAN HILL REGION OF MEGHALAYA

SANTOSH KORAV*, VISHRAM RAM, R KRISHNAPPA[1] AND N PREMARADHYA

School of Natural Resource Management, College of PG-Studies, Umiam-793103, Meghalaya, India

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Abstract

Field experiment was carried out during Kharif and Rabi seasons of 2016-17 at the mid altitudes of Meghalaya in the precincts of Sub Himalayan hill region to assess and quantify the extent of weed interference on growth and physiology of groundnut in both seasons of the year. Crop physiological parameters *viz.*, LAI, CGR, RGR, NAR, SPAD value, leaf thickness, specific leaf area, specific leaf weight and partitioning efficiency which are key for determining growth and yield of crop were documented periodically. The highest values of all the physiological attributes were found in weed free check, and lowest with weedy check. As weeds, biological agents with similar cellular and plant structure equally affect the crop in all sectors of growth and reproduction but it is not shared uniformly across all stages of crop growth but with increasing period of weed interference decrease the extent of damage to crop plants.

Introduction

Groundnut (*Arachis hypogea* L.) is a leading oilseed crop in India gaining unprecedented importance due to its low photosensitivity, indeterminate growth habit, mid season drought tolerance and wide adaptability in most of the agroclimatic situations. Uniqueness of this crop is its growth of vegetative and reproductive organs overlaps due to inter-organ competition for photo-assimilation and other metabolites which causes low fruiting/pod set efficiency hence affecting yield in unpredictable way (Pushp and Virender 2012). Groundnut is grown extensively under rainfed situation and under non-rainfed conditions. With available irrigation facility this crop can be grown in all the three seasons. In similar way, in receipt of 2 to 10 - 12 thousand millimetres of annual rainfall in sub Himalayan region, with ample of sunshine hours available throughout the year, it can be grown in kharif, Rabi and summer seasons of Meghalaya. But there are noticeable changes in productivity across the growth seasons as mostly the yield of Rabi season is lower compared to Kharif due to less occurrence of base temperature. Meagre availability of optimum photothermal indexing causes less growth and consequently affect number of peg formation as well as remarkably increases the length of growing period.

Besides, this season variation of growth and productivity of the crop, unwarranted exposure of the ground crop to myriad of biotic and abiotic factors during active growth stages of crop growth are equally responsible for low productivity of groundnut as their primary effect canopy growth, physiological efficiency and important peg formation stage. Considering biotic factors, weeds being unwanted plants with curse are key agents of innate crop damage because they are capable to reduce the yield of crop till 45 to 60 - 70% in the potential arable area of sub-Himalayan regions of Meghalaya with profuse growth, propensity and diversity of weeds. Groundnut, being initially slows growing crop (Senthil *et al*. 2004), bearing short plant height and underground pod

*Author for correspondence: <santoshkorav@gmail.com>. [1]Scientist, ICAR RC for NEH region, Umiam, Meghalaya, India.

forming habit which provides congenial space and environment for abundant weed growth. The computational stresses of weeds cause substantial yield losses (15 - 75%) depending on the season (Jat *et al*. 2011). Some common and noticeable weeds with their relative abundance are, *Galinsoga parviflora* (25%), *Cynodon dactylon* 28%, *Eleucine indica* (24%), *Ageratum conyzoides* (9%), *Euphorbia geniculata* (8%), *Amaranthus lividus* (6%) which predominately found in groundnut fields of hill agriculture. Weeds are more prominent in Kharif season due to timely and equal distribution of south-west monsoon which bless higher amount of rain fall with moderate to sufficient conducive growth temperature (18 to 30°C) for mesophytes. But in Rabi season, low base temperatures as well as absence or erratic distribution of rain fall affect the growth and plants population in great extent.

Higher weed populations in particular crop growing area significantly effect on growth and development of crop. The physiological and morphological attributes which determine the competitive ability of crops and weeds in terms of capture, explore and exploitation of available resources are utmost important for maximising and out-performing the crop fitness over weed (Swanton *et al*. 2015). Less weed population, lower biomass and canopy spread with minimum dry weight provides ample space for expression of genetic potential of crop in terms of optimum root growth and proliferation, nodulation, non-stressful expansion of shoot architecture and phenology of plant (Jayarama 1995). The characterisation of physiological parameters and agronomic traits can provide information on the extent of damage by the weed and immensely help in strategically programming the warranted control measures including the optimal timing, type of farm implement and duration of weed stress free period to farmers and land managers. At global level, impact of weeds causes more than $100 billion U.S. dollars of economic losses annually (Appleby *et al*. 2000) and demand around $25 billion U.S. dollars annual herbicide sales and movement across worldwide (Agrow 2003). For reducing this big dollar's value and environmental pollution with relentless usage of pesticide, greater understanding of crop-weed interactions has become very important and very essential in order to develop cost-effective and sustainable weed management practices to increasing yield. With rational and logical consideration of above facts and figures, present study aimed to evaluate and assess the physiological changes and quantify the impact on yield of ground nut crop in relation with crop-weed competition at different growth stages at college experimental unit of Umiam Meghalaya which ideally located at mid altitudes and moderate to heavy rainfall occurring area of sub-Himalayan region.

Materials and Methods

Field experiment was conducted at experimental farm of the College of Postgraduate Studies (CAU), Umiam, Meghalaya, India in both Kharif and Rabi seasons of the year 2016 - 2017. The experimental site was located at 091°54.72' E longitude and 25°40.886' N latitude and at an altitude of 950 m above the mean sea level (MSL). The soil of the experimental site is typical sandy clay loam in texture, soil pH (4.9), organic carbon (0.77%), NPKS (282.24, 13.04, 241.98, 1.6 kg/ha). The experiment was conducted in a randomized block design, replicated thrice with 12 treatments *viz.*, weeds until 15, 30, 45, 60, 75 days after emergence (DAE), weedy treatment and weed free until 15, 30, 45, 60, 75, weed free treatment. ICGS-76 is the variety of test crop i.e groundnut which was suitably sown during two experimental seasons i.e second fortnight of June (23rd June for Kharif) and November (22nd November for Rabi) with plant spacing of 40 × 10/cm^2 on flat beds. Recommended doses of N, P and K 25 : 60 : 60 NPK kg/ha (Full doses N, P and K) were effectively applied at the time of sowing. Other standard agronomic practices were followed during crop growth period and crop was harvested at right time of physiological maturity. Randomly ten plants were selected from each plot and regular biometric observations of

crop were recorded at appropriate days after emergence (DAE) to harvest with an interval of 15 days.

For leaf area calculation of all the photosynthetically active leaves, five representative plants were selected from each plot by using leaf area meter at 15, 30, 45, 60, 75 days after emergence and the LAI was calculated by using the following formula (Watson 1947).

$$LAI = \frac{\text{Leaf area } (cm^2)}{\text{Ground covering area } (cm^2)}$$

The fully expanded matured leaf more specifically, the fifth leaf from the top was used for specific leaf weight (SLW) and specific leaf area (SLA) measurement. Fifth leaf from the top was collected and leaf area was measured using leaf area meter immediately. Later, the leaf was dried in an oven at 60 ^{0}C to constant weight. Weight of the dried leaf was recorded and SLW and SLA were computed using the equation given below.

$$SLW = \frac{\text{Leaf weight}}{\text{Leaf area}} \qquad SLA = \frac{\text{Leaf area}}{\text{Leaf weight}}$$

Leaf thickness was measured using absolute digimetic Vernier calliper (Mitutoyocorp, Japan) with an accuracy of 0.01 mm and was expressed in mm. This measurement was taken in the broadest part of the matured leaf excluding major veins.

The rate of dry matter production per unit land area per unit time or Crop growth rate (CGR) was worked out by using formula proposed by Watson (1947) and expressed as g m^{-2} day^{-1} or mg day^{-1} cm^{-2}.

$$CRG = \frac{W2 - W1}{t2 - t1} \times \frac{1}{P}$$

where, W1 and W2 dry matter production (g) per plant at time t1 and t2, respectively, P = Ground area covered by plant (m^2)

The rate of increase in dry weight per unit dry weight expressed in mg g^{-1} day^{-1} was calculated using the formula suggested by Blackman (1919).

$$RGR = \frac{\log W2 - \log W1}{t2 - t1}$$

where, W1 and W2 are dry weight production (g) of plant at time t1 and t2 respectively.

Net assimilation rate (NAR) was determined by the formula given by Beadle (1987) expressed in mg cm^{-2} day^{-1}.

$$NAR = \frac{(W2 - W1)(\text{Log } LA1 - \text{Log } LA1)}{(t2 - t1)(LA2 - LA1)}$$

where, W_1 and W_2 are the dry matter accumulation (g), LA1 and LA2 are leaf area (cm^2) at time t1 and t2, respectively**.**

The chlorophyll content of the plant leaves was recorded at different stages with the help of solvent extraction methods for chlorophyll a, b and total chlorophyll content was also be determined by chlorophyll meter SPAD-502 plus. The observations will be recorded from the five plants in each plot and expressed as Soil Plant Analysis and Development (SPAD index).

For chlorophyll estimation the third leaves from top was selected as sample and grind with 80% acetone solution. The required amount was taken and absorbance was measured at 665 and 663 nm or Spectronic-20 for chlorophyll b, total chlorophyll and chlorophyll a, respectively. Further calculations were done by using the following formulae given by Arnon (1949).

Chl. a (mg/g FW) = (12.72 × A663 – 2.58 × A645)*(V/W)*(1/1000)

Chl. b (mg/g FW) = (22.87 × A645 – 4.67 × A663) *(V/W)*(1/1000)

Chl. a+b (mg/g FW) = (8.05 × A663 + 20.29 × A645)*(V/W)*(1/1000)

where V refers to the total volume of the extract and W refers to weight of the tissue taken for pigment measurements and A663 and A645 nm is the optical absorbance values recorded by UV-2100 at 663 and 645 nm, respectively. FW stands for fresh weight of the tissue.

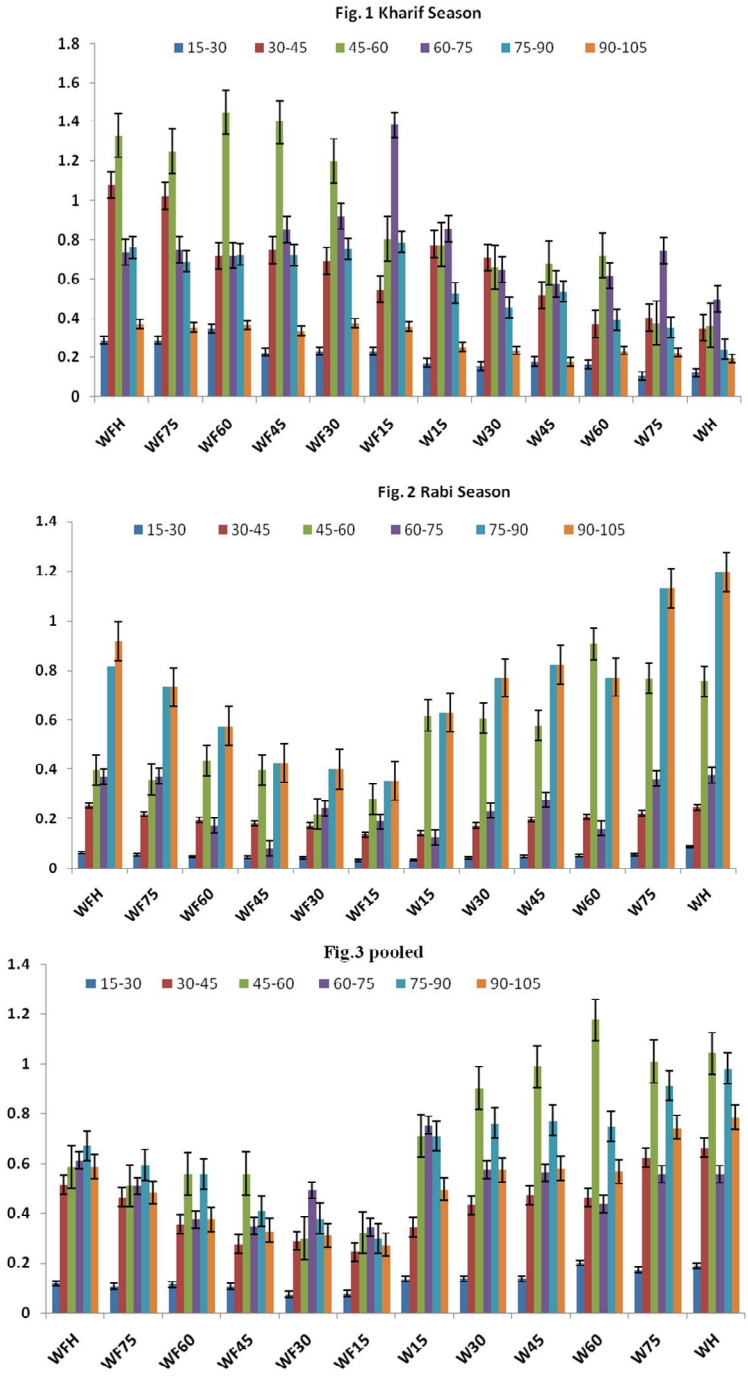
Partitioning efficiency was calculated as ratio of seed biomass to the total above ground biomass and it can also be expressed in terms of energy content of the seed to the energy content of total above ground biomass at full maturity (Fehr *et al.* 1971).

The analysis and interpretation of experimental data were performed using the Fisher's method of analysis of variance technique as described by Gomez and Gomez (1984). The level of significance used in 'F' and 't' test was at p = 0.05. Critical difference values were calculated wherever the 'F' test was significant.

Results and Discussion

The leaf area index of tested groundnut crop was significantly affected by increasing the length of weed interference period, whereas, on the other hand, it was positively influenced by the increasing span of weed free period. Long weed free treatments obtained higher leaf area, canopy growth and leaf area index (Table 1). However, the lowest was observed in weedy treatment with no weed control measures. The progressive development of leaves follow a definite pattern, further growth and inception of new leaves depending upon the increase in height and development of new branches in the groundnut plant with relation to the length of internodes. As the canopy development of the weeds increasingly restricted the growth and development of the plants, consequently, the foliage coverage of the groundnut was at stake and abridged. Further, it also parallely disturbed the nutrient supply, its allelopathic effect, low water potential and nutrient uptake variation by weeds which resulted in reduced growth and development of leaves as a result lower leaf area index. At later stages of crop growth and leaf senescence that occurs might be another reason of lower leaf area and leaf area index after peak growth stage of 60 days stage. In similar way leaf areas of crop were found to reduce significantly with the increase of the duration of weed competition in rice (Munene *et al.* 2008).

Weeds were adversely affected on growth attributes of the crop *viz.*, CGR, RGR and NAR during both seasons (Tables 2 - 3 and Figs 1 - 3). The CGR and RGR initially increased up to 45 - 60 DAE after that declined progressively up to harvesting in both seasons. CGR was significantly influenced at 45 - 60 DAE in the treatment of weed free check with 1.33, 0.76 and 1.04 mg/day/cm in Kharif, Rabi and pooled, respectively than the other weed free and weedy treatments. Similarly, RGR was also up to 30 to 45 DAE, reported maximum in Kharif than Rabi, after which the Rabi season dominated CGR in terms of higher values than Kharif up to Harvesting (Figs 1, 2 and 3). During Kharif, maximum RGR was significantly influenced at 30 - 45 DAE in weed free check with 0.038 mg g/day and in Rabi season at 45 - 60 DAE in weed free check with 0.031 mg/g/day (Table 2). The net assimilation rate (NAR) in the plant increased with the progress of the growth period of the groundnut during both the seasons of the experimentations (Table 3). However, NAR of Kharif season was higher than the Rabi seasons irrespective of the



Figs 1- 3: Crop growth rate (mg/day/cm^2) of groundnut as influenced periodically by different stages of weedy and weeds free treatments.

Table 1. Mean leaf area index (LAI) of groundnut as influenced periodically by different stages of weedy and weeds free treatments.

Treatments	Kharif	Rabi	Pooled	Kharif	Rabi	Pooled	Kharif	Rabi	Pooled	Kharif	Rabi	Pooled	Kharif	Rabi	Pooled
	15 DAE			30 DAE			45 DAE			60 DAE			75 DAE		
Weeds until 15 days	0.26a	0.13a	0.20a	0.41de	0.23a	0.32c	2.05ab	1.00a	1.52abc	2.37ab	1.10de	1.73de	2.42bc	1.58de	2.00cde
Weeds until 30 "	0.22ab	0.11ab	0.16b	0.4de	0.19ab	0.30c	1.91bcd	0.83b	1.37bcd	2.24ab	1.09de	1.66ef	2.35c	1.56de	1.96cde
Weeds until 45 "	0.22ab	0.11ab	0.16b	0.37de	0.19ab	0.28c	1.65cd	0.81b	1.23cd	2.07c	1.00de	1.53fg	2.35c	1.44e	1.89de
Weeds until 60 "	0.18bc	0.09bc	0.14bc	0.37de	0.16bc	0.26c	1.20e	0.68cd	0.94e	1.85d	0.99de	1.42gh	2.18d	1.44e	1.81e
Weeds until 75 "	0.18bc	0.09bc	0.14bc	0.37de	0.16bc	0.26c	1.18e	0.68cd	0.93e	1.73de	0.99de	1.36gh	2.17d	1.43e	1.80e
Weedy plot	0.18bc	0.09bc	0.13c	0.36e	0.15bc	0.25c	1.13e	0.65cd	0.89e	1.68e	0.95e	1.32h	2.12d	1.38e	1.75e
Weed free until 15 days	0.16c	0.08c	0.12c	0.45cd	0.14c	0.29c	1.61d	0.58d	1.10de	2.23b	1.21cd	1.72de	2.48ab	1.75cd	2.11bcd
Weed free until 30 "	0.17bc	0.09bc	0.13c	0.50c	0.15bc	0.32c	1.9bcd	0.63d	1.27bcd	2.36ab	1.34c	1.85de	2.48ab	1.91bc	2.20bc
Weed free until 45 "	0.17bc	0.09bc	0.13c	0.53c	0.15bc	0.34bc	1.98abc	0.77bc	1.38bcd	2.39ab	1.43c	1.91cd	2.49ab	2.05b	2.27ab
Weed free until 60 "	0.21ab	0.11ab	0.16b	0.65b	0.19ab	0.42ab	2.14ab	0.80b	1.47abc	2.41a	1.76b	2.08bc	2.52ab	2.51a	2.51a
Weed free until 75 "	0.21ab	0.11ab	0.16b	0.66b	0.19ab	0.42ab	2.31a	0.81b	1.56ab	2.46b	1.80b	2.13b	2.53a	2.44a	2.48a
Weed Free plot	0.26a	0.13a	0.19a	0.74a	0.23a	0.49a	2.39a	0.98a	1.68a	2.62a	2.02a	2.32a	2.56a	2.47a	2.51a
SE (m) ±	0.02	0.01	0.01	0.03	0.01	0.01	0.11	0.04	0.04	0.05	0.07	0.03	0.03	0.09	0.03
CD (p = 0.05)	0.05	0.02	0.02	0.07	0.04	0.03	0.32	0.11	0.12	0.15	0.20	0.09	0.09	0.26	0.10

*Figures not sharing the same letters in the same column differ significantly at $p < 0.05$.

Table 2. Relative growth rate (mg/g/day) of groundnut as influenced periodically by different stages of weedy and weeds free treatments.

Treatments	Kharif	Rabi	Pooled	Kharif	Rabi	Pooled	Kharif	Rabi	Pooled
	15 - 30 DAE			30 - 45 DAE			45 - 60 DAE		
Weeds until 15 days	0.027e	0.021b	0.024de	0.038a	0.033a	0.035a	0.016a	0.021f	0.018de
Weeds until 30 "	0.028e	0.021b	0.024de	0.039a	0.032a	0.035a	0.015a	0.022ef	0.018de
Weeds until 45 "	0.032cde	0.020b	0.026bcde	0.031abc	0.032a	0.032ab	0.018a	0.027cdef	0.023bcde
Weeds until 60 "	0.032cde	0.020b	0.026bcde	0.027c	0.032a	0.029b	0.022a	0.026cdef	0.024abcd
Weeds until 75 "	0.025e	0.020b	0.022e	0.033abc	0.032a	0.033ab	0.015a	0.018f	0.016e
Weedy plot	0.031de	0.019b	0.025cde	0.030abc	0.032a	0.031ab	0.016a	0.025def	0.021cde
Weed free until 15 days	0.044ab	0.019b	0.032ab	0.03abc	0.032a	0.031ab	0.019a	0.040ab	0.029ab
Weed free until 30 "	0.040abc	0.020b	0.030abcd	0.034abc	0.032a	0.033ab	0.023a	0.035abc	0.029ab
Weed free until 45 "	0.036bcd	0.021b	0.029abcde	0.035abc	0.032a	0.034ab	0.025a	0.031bcd	0.028abc
Weed free until 60 "	0.045a	0.021b	0.033a	0.028bc	0.032a	0.030ab	0.024a	0.041a	0.032a
Weed free until 75 "	0.040abc	0.021b	0.030abcd	0.037ab	0.032a	0.035ab	0.018a	0.035abc	0.026abc
Weed free plot	0.036bcd	0.026a	0.031abc	0.038ab	0.028b	0.033ab	0.019a	0.031bcde	0.025abcd
SE(m) ±	0.0026	0.0006	0.0010	0.0031	0.0007	0.0012	0.0037	0.0028	0.0017
CD (p = 0.05)	0.0075	0.0019	0.0027	0.0091	0.0020	0.0033	NS	0.0083	0.0048

contd. from right side

Treatments	Kharif	Rabi	Pooled	Kharif	Rabi	Pooled	Kharif	Rabi	Pooled
	60 - 75 DAE			75 - 90 DAE			90 - Harvest		
Weeds until 15 days	0.010a	0.011ab	0.011ab	0.006a	0.016ab	0.010a	0.002a	0.015abc	0.009a
Weeds until 30 "	0.010a	0.012a	0.011ab	0.005a	0.015ab	0.010ab	0.002a	0.015ab	0.009a
Weeds until 45 "	0.009a	0.006ab	0.008ab	0.007a	0.014bcd	0.010a	0.002a	0.014bcd	0.008a
Weeds until 60 "	0.011a	0.003b	0.007ab	0.005a	0.013cde	0.009ab	0.003a	0.013cde	0.008a
Weeds until 75 "	0.016a	0.012ab	0.014a	0.006a	0.013de	0.009ab	0.003a	0.013de	0.008a
Weedy plot	0.013a	0.009ab	0.011ab	0.005a	0.012e	0.008b	0.003a	0.012e	0.007a
Weed free until 15 days	0.018a	0.004ab	0.011ab	0.007a	0.015bc	0.011a	0.003a	0.015abc	0.009a
Weed free until 30 "	0.01a	0.007ab	0.009ab	0.006a	0.015ab	0.011a	0.003a	0.015ab	0.009a
Weed free until 45 "	0.009a	0.008ab	0.008ab	0.006a	0.016ab	0.011a	0.002a	0.016ab	0.009a
Weed free until 60 "	0.007a	0.004b	0.003b	0.006a	0.016ab	0.011ab	0.003a	0.016ab	0.009a
Weed free until 75 "	0.007a	0.008ab	0.008ab	0.005a	0.017a	0.011a	0.002a	0.017a	0.009a
Weed free plot	0.007a	0.008ab	0.008ab	0.006a	0.017a	0.011a	0.002a	0.017a	0.01a
SE(m) ±	0.0032	0.0026	0.0015	0.0010	0.0006	0.0004	0.0006	0.0006	0.0003
CD (p = 0.05)	NS	0.0076	0.0043	NS	0.0017	0.0012	NS	0.0018	NS

*Figures not sharing the same letters in the same column differ significantly at $p < 0.05$ (in both tables).

growth stages. Among the different weed free treatments weed free up to 30 to 45 DAE produced higher NAR with 0.33, 0.27 mg cm^2/day in Kharif and pooled respectively, and 0.21 mg cm^2/day during Rabi season. However, CGR, RGR and NAR initially exhibited increasing trend which reached maximum at active vegetative stage after that decreased gradually up to its harvesting stage. It might be due to CGR and dry matter accumulation from initial to reproductive stage, will be more as compared to later stages. Once crop reached to reproductive stage it started translocations and remobilisation of photosynthetic material from source to sink. This might be due to the declining of the RGR and NAR after achieving grand growth phase in groundnut crop. Similarly, in the present study, at later stages crop was infested with insect cause early leaf shedding and senescence at important physiological growth stages. The similar results were supported by Banik *et al*. (2009) who reported that decline in RGR towards physiological maturity could be due to leaf shedding, shadow or less light transmittance of upper leaves over the lower leaves which reduce the photosynthetic capacity of the lower leaves and finally loss of leaves due to pest attack in groundnut. However, the weed free treatments accumulated maximum NAR as compared to weedy treatments**.** Olayinka and Etejere (2015) observed that in two groundnut varieties at peak periods between 8 and 8-10 WAS in MK 373 and Samnut 10, respectively. Highest NAR in weed free plots or plot raised under rice straw mulch + one hand weeding at 6 WAS and lowest NAR was recorded in weedy check.

The chlorophyll content measured using SPAD chlorophyll meter reading (SCMR) was found to decrease with increasing duration of weed interference period during both the seasons of the experimentations. Completely weed free plots accumulated higher SPAD value than the other weed free periods and weedy plots of different intervals in kharif, Rabi and pooled. At 60 days after sowing (DAS) the SCMR value was higher in weed-free check due to higher accumulation and retention of chlorophyll content of leaves in Kharif, Rabi and pooled. Moreover, minimum SCMR was found in the weedy check because weeds utilize higher incident sunlight as compared to crop. It affects leaf chlorophyll content in groundnut. Hakim *et al.* (2013) reported that the chlorophyll content (SCMR value) was found to decrease with increasing duration of weed interference period. The maximum chlorophyll content (42.10 SCMR) was observed in the long weed-free treatment followed by 75 days weed-free and 30 days weedy treatments (more than 41) while the minimum chlorophyll content was found in the season-long weedy treatments. Leaf chlorophyll is the main pigment and growth factor for healthy photosynthesis in plants. Increase of the weed free period increases the leaf chlorophyll content by increased synthesis or reduced degradation, but the reduction trend increased with increasing the duration of weedy period. It is strongly influenced by environmental factors (Qiu *et al.* 2007).

Higher leaf thickness was recorded in weeds until 15 DAE during both the seasons individually and in pooled data of experimentation at 45 DAS. Similarly, at 60 DAS higher leaf thickness was recorded at weed free check (Table 4). At 45 days, weeds showed synergistic effect and at 60 days high utilisation of light for their canopy development, numbers of leaves and leaf thickness in weed free treatments, but in weedy treatments minimum leaf thickness was recorded. This is due to increase of weed density which affects plant leaf mesophyll performance.

Different weed regimes show their significant effect on specific leaf area and specific leaf weight (Table 5). During crop growth at 45 days after sowing (DAS) stage, above two parameters were observed maximum in weed affected treatments until 15 DAE but at 60 DAS it was found in season long weed free treatment. Similarly, initial free treatments showed increasing trend and initial weedy treatments were showed deceasing trend. It clearly indicated that, with the increase of crop weed competition, weeds outperforms the crops in utilising the maximum amount of water from different depth of soil through their different and profuse root growth pattern as well as root adaptive mechanisms that influence and uptake to utilises more nutrients,

Table 3. Net Assimilation rate (mg/cm²/day) of groundnut as influenced periodically by different stages of weedy and weeds free treatments.

Treatments	Kharif	Rabi	Pooled	Kharif	Rabi	Pooled	Kharif	Rabi	Pooled	Kharif	Rabi	Pooled
	15 - 30 DAE			30 - 45 DAE			45 - 60 DAE			60 - 75 DAE		
Weeds until 15 days	0.22cde	0.16bc	0.19bc	0.33a	0.21ab	0.27a	0.15bc	0.17de	0.16def	0.15a	0.12a	0.14a
Weeds until 30 "	0.22cde	0.16bc	0.19bc	0.32a	0.22ab	0.27a	0.14bc	0.17de	0.15def	0.12a	0.12a	0.12a
Weeds until 45 "	0.27bcde	0.14c	0.21abc	0.26a	0.20ab	0.23ab	0.16abc	0.21cde	0.19cde	0.11a	0.06ab	0.09a
Weeds until 60 "	0.27bcde	0.16bc	0.21abc	0.23a	0.22ab	0.23ab	0.21abc	0.21cde	0.21bcd	0.13a	0.03b	0.08a
Weeds until 75 "	0.17e	0.15bc	0.16c	0.25a	0.21ab	0.23ab	0.11c	0.12e	0.11f	0.17a	0.09ab	0.13a
Weedy plot	0.21de	0.12c	0.17c	0.22a	0.17b	0.20b	0.12c	0.16de	0.14ef	0.11a	0.07ab	0.09a
Weed free until 15 days	0.36ab	0.14c	0.25ab	0.26a	0.2ab	0.23ab	0.19abc	0.31ab	0.25abc	0.25a	0.04b	0.15a
Weed free until 30 "	0.34ab	0.16bc	0.25ab	0.29a	0.22ab	0.26ab	0.25ab	0.29abc	0.27ab	0.17a	0.06ab	0.11a
Weed free until 45 "	0.33abc	0.21ab	0.27a	0.30a	0.24a	0.27a	0.28a	0.24bcd	0.26ab	0.15a	0.07ab	0.11a
Weed free until 60 "	0.39a	0.16bc	0.28a	0.25a	0.22ab	0.24ab	0.27a	0.34a	0.31a	0.13a	0.03b	0.06a
Weed free until 75 "	0.32abcd	0.17abc	0.24ab	0.34a	0.23ab	0.28a	0.23abc	0.27abc	0.25abc	0.13a	0.07ab	0.10a
Weed free plot	0.28bcde	0.22a	0.25ab	0.33a	0.21ab	0.27a	0.23abc	0.23bcd	0.23abc	0.12a	0.07ab	0.10a
SE(m) ±	0.034	0.018	0.014	0.037	0.017	0.015	0.035	0.029	0.017	0.044	0.023	0.018
CD (p = 0.05)	0.098	0.053	0.040	NS	0.050	0.043	0.103	0.085	0.047	NS	0.067	NS

*Figures not sharing the same letters in the same column differ significantly at $p < 0.05$.

Table 4. Mean chlorophyll index (SCMR) and leaf thickness of groundnut as influenced periodically by different stages of weedy and weeds free treatments.

Treatments	Kharif	Rabi	Pooled	Kharif	Rabi	Pooled	Kharif	Rabi	Pooled	Kharif	Rabi	Pooled
	SPAD 45 DAS			SPAD 60 DAS			Leaf thickness 45 DAS			Leaf thickness 60 DAS		
Weeds until 15 days	40.66ab	39.50a	40.08a	46.79ab	41.76a	44.27ab	274.00a	260.30a	267.20a	422.00ab	398.10ab	410.00ab
Weeds until 30 "	37.79abc	32.82bc	35.31bcd	41.41ab	36.96abc	39.19cd	236.00b	224.20ab	230.10bc	416.00abc	399.00ab	407.50ab
Weeds until 45 "	35.26abc	29.89bcd	32.58cd	39.97b	35.67abc	37.82cde	230.00b	218.50ab	224.30bcd	408.00abc	381.00bc	394.50cd
Weeds until 60 "	34.74abc	30.16bcd	32.45cde	39.64b	35.38abc	37.51cde	219.30b	208.40ab	213.90bcd	405.30abc	388.60ab	396.90cd
Weeds until 75 "	32.13abc	28.15cd	30.14de	37.98b	33.90bc	35.94e	214.70b	203.90b	209.30d	400.70c	366.70c	383.70e
Weedy plot	31.53e	25.68b	28.61e	34.42b	30.72c	32.57e	212.70b	202.00b	207.40d	399.30c	378.10bc	388.70de
Weed free until 15 "	34.66bc	28.83bcd	31.75de	37.13b	33.14bc	35.14de	218.00b	207.10ab	212.60cd	404.00c	384.90bc	394.50cd
Weed free until 30 "	38.26abc	32.53bc	35.39cd	41.07ab	36.65abc	38.86cd	220.70b	209.70ab	215.20bcd	406.70abc	372.40c	389.50de
Weed free until 45 "	38.35abc	33.11bc	35.73abcd	42.09ab	37.56abc	39.83bcd	223.30b	212.20ab	217.80bcd	412.70abc	378.10bc	395.40cd
Weed free until 60 "	39.88abc	34.09b	36.98abc	43.94ab	39.22ab	41.58bc	226.70b	215.30ab	221.00bcd	414.00abc	394.30ab	404.10abc
Weed free until 75 "	40.65ab	32.98bc	36.82abc	44.47ab	39.69ab	42.08bc	228.00b	216.60ab	222.30bcd	416.70abc	387.60ab	402.10bc
Weed free plot	45.42a	39.19a	42.30ab	47.44a	42.34a	44.89a	239.30b	227.30ab	233.30b	425.30a	402.00a	413.60a
SE(m) ±	2.72	1.65	1.17	2.92	2.13	1.33	10.1	8.6	4.9	5.3	3.3	2.3
CD (p = 0.05)	7.96	4.84	3.31	8.55	6.24	3.76	29.6	25.3	13.8	15.6	9.8	6.5

*Figures not sharing the same letters in the same column differ significantly at $p < 0.05$.

Table 5. Mean specific leaf area (cm^2/g) and specific leaf weight (g/cm^2) as influenced periodically by different stages of weedy and weeds free treatments in groundnut.

Treatments	Specific leaf area						Specific leaf weight					
	Kharif	Rabi	Pooled	Kharif	Rabi	Pooled	Kharif	Rabi	Pooled	Kharif	Rabi	Pooled
	45 DAE			60 DAE			45 DAE			60 DAE		
Weeds until 15 days	47.96bcd	40.90c	44.43b	50.80a	44.00bc	47.40a	0.048a	0.044a	0.046a	0.032abc	0.033ab	0.032bc
Weeds until 30 "	43.73cd	36.88d	40.30b	41.41bc	36.20de	38.81bc	0.037b	0.034ab	0.035b	0.028bcde	0.028abc	0.028cde
Weeds until 45 "	42.23de	36.75e	39.49b	36.73bc	32.73e	34.73cd	0.034bc	0.031bc	0.032bc	0.027bcde	0.026bcd	0.027def
Weeds until 60 "	29.94f	26.33ef	28.14c	35.54bcd	32.34ef	33.94de	0.033bcd	0.030bc	0.032cd	0.026cde	0.024ccd	0.025efg
Weeds until 75 "	25.45fg	19.21fg	22.33d	35.35bcd	29.27f	32.31de	0.031bcde	0.029bc	0.030cd	0.025cde	0.023d	0.024efg
Weedy plot	20.12g	19.42g	19.77d	33.26cd	25.98f	29.62e	0.025fg	0.023d	0.024gh	0.022e	0.021d	0.021g
Weed free until 15 "	34.06ef	30.61d	32.34c	26.73d	23.16fcd	24.94f	0.023g	0.021d	0.022h	0.023de	0.023cd	0.023fg
Weed free until 30 "	41.64de	37.64d	39.64b	33.63cd	25.04cd	29.34ef	0.026efg	0.024cd	0.025fg	0.028bcde	0.027bcd	0.027def
Weed free until 45 "	44.28cd	39.40c	41.84b	34.90bcd	31.68ab	33.29de	0.027defg	0.025cd	0.026fg	0.031abcd	0.029abc	0.030bcd
Weed free until 60 "	52.59abc	47.44bc	50.02a	36.44bc	30.57a	33.50de	0.029cdef	0.027bc	0.028def	0.031abcd	0.032abc	0.032bc
Weed free until 75 "	55.27ab	47.17ab	51.22a	36.96bc	31.76a	34.36cde	0.030cdef	0.028bc	0.029de	0.035ab	0.032abc	0.034ab
Weed free plot	57.94a	45.88a	51.91a	43.74ab	35.35a	39.55b	0.030cdef	0.028cd	0.029de	0.038a	0.036a	0.037a
SE(m) ±	2.92	1.66	1.24	2.88	1.76	1.25	0.002	0.002	0.001	0.002	0.002	0.001
CD (p = 0.05)	8.55	4.87	3.49	8.45	5.16	3.52	0.005	0.005	0.003	0.007	0.005	0.003

*Figures not sharing the same letters in the same column differ significantly at $p < 0.05$.

Table 6. Number of branches, 50% flowering and Number of pegs as influenced periodically by different stages of weedy and weeds free treatments in groundnut.

Treatments	No. of branches			50% flowering (DAE)			No. of pegs		
	Kharif	Rabi	Pooled	Kharif	Rabi	Pooled	Kharif	Rabi	Pooled
Weeds until 15 days	11.00cd	9.89de	10.45d	42.67a	148.00f	95.33abcd	17.89c	15.03de	16.46de
Weeds until 30 "	9.67de	8.68f	9.17e	42.00b	149.67cde	95.83abc	17.11c	13.23ef	15.17de
Weeds until 45 "	9.33de	8.90ef	9.11d	42.00b	149.00def	95.50abcd	16.44c	12.55f	14.50e
Weeds until 60 "	7.67ef	7.06g	7.36f	41.33c	151.33ab	96.33a	12.00d	9.11g	10.55f
Weeds until 75 "	6.66f	6.14g	6.40fg	40.33d	152.00a	96.17ab	11.33d	8.38g	9.86f
Weedy plot	6.00f	4.94h	5.47g	40.00d	152.33a	96.17ab	10.11d	7.98g	9.05f
Weed free until 15 days	12.33bc	10.05de	11.19cd	40.0d	151.00abc	95.5abcd	20.33bc	14.30def	17.32cd
Weed free until 30 "	12.33bc	10.05de	11.19cd	40.00d	150.33bcd	95.17abcd	23.33ab	15.78cd	19.56bc
Weed free until 45 "	12.56bc	11.72bc	12.14bc	40.00d	149.00def	94.50bcde	24.00ab	17.36bc	20.68b
Weed free until 60 "	12.67bc	10.82cd	11.74c	40.00d	148.67ef	94.33cde	24.00ab	17.72bc	20.86ab
Weed free until 75 "	13.89b	12.14b	13.01b	40.00d	148.00f	94.00de	24.33ab	18.35ab	21.34ab
Weed free plot	16.66a	14.70a	15.68a	40.00d	146.33g	93.17e	26.67a	19.94a	23.30a
SE(m) ±	0.70	0.38	0.29	0.16	0.45	0.18	1.44	0.71	0.60
CD (p = 0.05)	2.04	1.12	0.83	0.46	1.33	0.50	4.24	2.10	1.68

*Figures not sharing the same letters in the same column differ significantly at $p < 0.05$. DAE - days after emergence.

CO_2 and light. These resources are very important in canopy development especially CO_2 which upon increase in concentration increased these parameters in plant (Kimball and Bindi 2002). Lawson *et al.*, (2002) reported an increase in leaf thickness and also in leaf area under weed infestation. The extra photosynthate, produced by an initial stimulation of CO_2 assimilation, is not used primarily to create a larger leaf area (thereby increasing light interception) but seems to be used in the development of thicker leaves, possibly by the accumulation of starch in the chloroplasts (Schapendonk *et al*. 1989).

Kharif season was getting maximum number of branches as compared to rabi and pooled of experimentation (Table 6). Initial diurnal temperature variation adversely affect on development of branches in rabi groundnut. However, the maximum number of branches was found in weed free up to harvest in both seasons. It might be due to less inter and intra competition for resources (nutrient, space and light) in groundnut.

Table 7. Harvest index and partition efficiency as influenced periodically by different stages of weedy and weeds free treatments in groundnut.

Treatments	Harvest index (%)			Partitioning efficiency (%)		
	Kharif	Rabi	Pooled	Kharif	Rabi	Pooled
Weeds until 15 days	48.11d	21.84cd	24.11bc	61.06c	49.72c	55.39c
Weeds until 30 "	46.83e	22.72a	24.81a	53.24e	43.30e	48.27e
Weeds until 45 "	43.84g	20.76e	22.73e	56.58d	46.32d	51.45d
Weeds until 60 "	44.91fg	20.69e	22.63e	49.09f	38.68g	43.89g
Weeds until 75 "	41.93h	20.60e	22.53e	44.23h	34.98h	39.61i
Weedy plot	51.34a	18.94g	21.63f	42.95h	32.53i	37.74j
Weed free until 15 days	45.52ef	20.22e	22.30e	43.25h	34.76h	39.00ij
Weed free until 30 "	46.48e	19.64f	21.52f	64.18b	51.78b	57.98b
Weed free until 45 "	48.66cd	21.40d	23.55d	62.28c	50.85bc	56.56c
Weed free until 60 "	49.50bc	22.15bc	24.20bc	50.86f	41.10f	45.98f
Weed free until 75 "	49.71bc	22.40ab	24.48ab	47.03g	38.03g	42.53h
Weed free plot	50.24ab	21.84cd	23.86cd	68.35a	55.48a	61.91a
SE(m) ±	0.43	0.18	0.10	0.62	0.43	0.28
CD (p = 0.05)	1.27	0.51	0.28	1.81	1.26	0.78

*Figures not sharing the same letters in the same column differ significantly at $p < 0.05$.

In general, Rabi season takes more days to flowering compared to Kharif season individually and in pooled data of the experimentation (Table 6). The amount of cumulative accumulated heat units (GDD) required for groundnut flowering was achieved within short period of time under Kharif season, whereas, in Rabi season it took higher number of days to accumulate same cumulative accumulated heat units (GDD). This might be due to the reason for delayed flowering in Rabi season. It might be due to lower temperature during initial crop growth stage and not able to fulfil the required amount of heat units or other factor required flowering. The maximum number of days to flowering was observed in weed affected plots until 15 DAE in Kharif alone while, Rabi and pooled it was observed under weedy up to harvest. Weed grows faster than the crop and outperforming covers the entire crop canopy quickly and it adversely affects crop

photosynthetic activity. For getting required amount of heat unit's plants were programmed to increase their respective growth stages like flowering, pegging and their maturity.

Maximum number of pegs/plant in Kharif is followed by pooled than the Rabi season. The highest number of pegs/plant was recorded with different weed free periods than the throughout weedy plots. Among the weedy and weed free plots maximum numbers of pegs formed in weed free check in kharif, rabi and pooled data of experimentation(Table 6).

The mean harvest index (HI) significantly differed in different weedy and weed free treatments kharif season was getting higher HI than rabi and pooled. Maximum HI was observed in weeds until 15 DAE in kharif, Rabi and pooled data (Table 7).

The partitioning efficiency significantly differed in different weedy and weed free treatments and its values were higher in Kharif season than Rabi and pooled. The higher partitioning efficiency was observed in weed free check in Kharif, Rabi and pooled data of experimentation.

The study revealed that higher value of physiological parameters was found in long weed free treatments and lowest was in long weedy treatment. However, initial weed free treatments getting higher physiological efficiency due to their initial crop growth is slower and weeds are taken/harnessed advantage to utilise all available resources efficiently causing reduced yield and ecological fitness to crop.

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