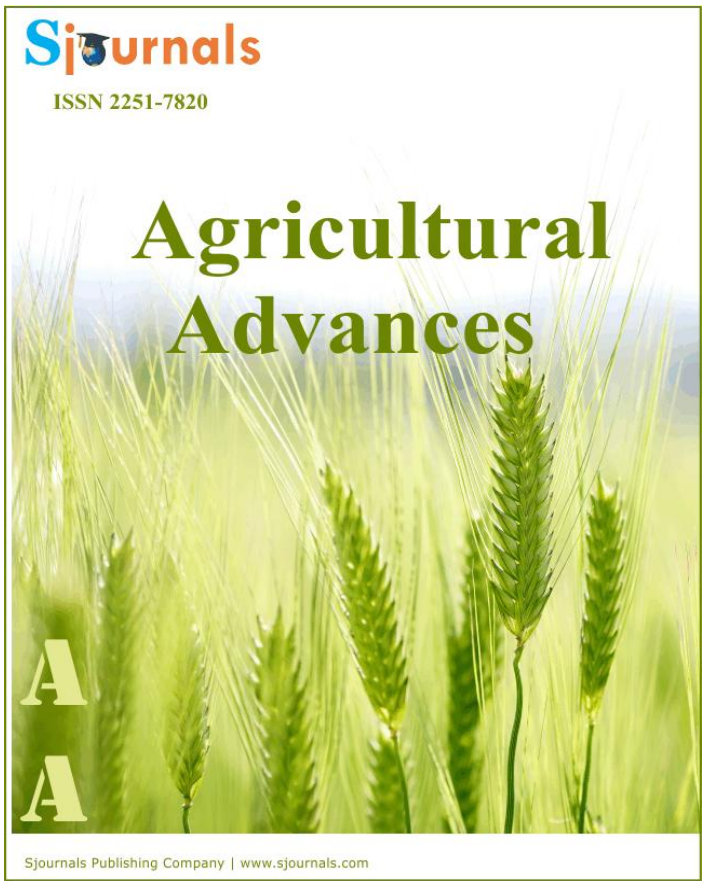

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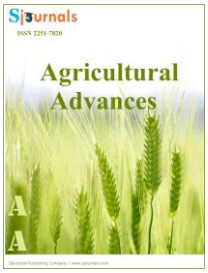


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Original article

# Effect of plant population dynamics and different weed free regimes on growth, yield and quality of peanut (*Arachis hypogaea* L.)

**Saiful Islam[a], Kaium Chowdhury[a], Abdur Rahman Sarker[b], Ayman EL Sabagh[c], Celaleddin Barutcular[d], Mohammad Sohidul Islam[f,*]**

[a]*Agricultural Training Institute (Department of Agricultural Extension), Gaibanda, Bangladesh.*
[b]*Department of Agronomy, Bangladesh Agricultural University, Bangladesh.*
[c]*Department of Agronomy, Faculty of Agriculture, Kafrelsheikh University, Egypt.*
[d]*Department of Field Crops, Faculty of Agriculture, Cukurova University, Turkey.*
[f]*Department of Agronomy, Hajee Mohammad Danesh Science and Technology University, Bangladesh.*

*Corresponding author; Department of Agronomy, Hajee Mohammad Danesh Science and Technology University, Bangladesh.

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ABSTRACT

Productivity of groundnut (*Arachis hypogaea* L.) in Bangladesh is very low, due to many limiting factors beset in its cultivation. Plant density and weed competition in crop constitute the main limiting factors. In order to combat the problems, the optimum plant density and most appropriate weeding period for good production in groundnut has been investigated at Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh, Bangladesh. Two plant density viz. 200,000 and 400,000 plants $ha^{-1}$, and seven weed competition periods from 0, 25, 40, 55, 70, 85 DAS and up to harvesting time were studied. Nineteen species of weeds representing 10 families were found to grow and population density was 150 plants $m^{-2}$. The major infesting species of weeds were *Cyperus rotundus* L. (Mutha), *Chenopodium album* L. (Bathua), *Physalis heterophylla* L. (Foska begun), *Gnaphalium luteo-album* L. (Shwetomuli) and *Paspalum disticum* L. (Knot grass) which constituted about 84.66% of the total weed population. *Cyperus rotundus* alone shared the maximum relative density (57%) having 85.5 plants $m^{-2}$ area of total weed vegetation and also shared the maximum intensity of infestation (2.85). Intensity of weed infestation was always higher at lower plant density.

Weed dry matter production was higher at a density of 200000 plants compared to 400000 plants $ha^{-1}$. In contrast, weed dry weight was progressively increased with increasing weed competition period and it was the highest in unweeded plot and critical period of weed competition appeared at 40 DAS. Weed competition period from zero to 40 DAS and thereafter weed free up to crop harvest with a density of 400000 plants $ha^{-1}$ gave the highest pod yield The pod yield was found to have a significant negative correlation with weed dry matter production i.e. an increase in the dry matter production will lead to a decrease in the yield of pods.



## 1. Introduction

Groundnut (*Arachis hypogaea* L.) is one of the most important oil crops under Leguminosae family grown in many tropical and sub-tropical countries. It occupies the fourth place among the oil crops in the world both in area and production next to soybean, sunflower and cotton (FAO, 2015; Garko et al., 2016), and stands first in terms of yield and third in respect of total oil crops area and production in Bangladesh (BBS, 2015). It is highly nutritious crop and contains about 48% oil, 25-30% protein, 20% carbohydrate, B and E vitamins and higher quantity of linoleic acid (Reddy and Kaul, 1986; Sarker et al., 2015). It is also used to prepare edible oil, biscuit, milk, butter and other necessary industrial products. A large portion of pods are fried and consumed directly, aerial parts are being used as fodder and the husks as fuel in Bangladesh. It enriches the soil by fixing atmospheric nitrogen about 40-80 $kgha^{-1}$ (Islam and Noor, 1982).

Oil seed crops produce only 40% of required edible oil in Bangladesh (Sarker et al., 2015). To make the country self-sufficient in edible oil, it is extremely necessary to increase the production of oil crops including groundnut. There is ample scope for expanding groundnut cultivation without affecting the major crops and that's why productivity of the crop must be increased. But the yield of the crop is very low in Bangladesh than the other countries and the lower yield of the crop is partly due to the low yielding cultivars and partly due to the lack of appropriate agronomic practices like population dynamics, weed infestation etc. Plant population and weeds are recognized as being of major importance for the low yields of groundnut in Bangladesh agriculture. Optimum plant population of groundnut per unit area gave positive response to higher yield (Agasimani et al., 1984; Salem et al., 1984; Patel et al., 1985; Ahmed et al., 2011). During crop growth, many weeds cause losses in groundnut yield by competing for water, space, light and nutrients. It then appears necessary to maintain the crops in a weed-free condition during this critical period to maintain high yields. The critical period of weed interference is defined as the crop growth period when it must be kept weed-free to prevent yield loss caused by weed interference (Weaver and Tan, 1987; Van Acker et al., 1993). Caussanel (1989) defined it as the period when weed: crop competition is at a maximum and induces a measurable yield loss. Weeds are estimated to reduce yield by 46-55% (Sibuga et al., 1989), 80-100% (Hamada et al., 1989), 18-70% (Anon, 2004). Yield losses have been observed in Senegal (28%) and Mali (33%) (Lavabre, 1988). Several studies indicated that increasing the duration of weed free period gave positive response to higher yield (Patel et al., 1985; Kulandaivelu and Morachan, 1981) and critical period of crop-weed competition in groundnut appeared from 2 to 8 weeks (Tewari et al., 1989), 2.6 to 8 weeks (Wesley et al., 2008). There has been little published information available on weed infestation period with maintaining optimum plant population in cropping systems in this environment. The present study was, therefore, focused to investigate the morphological adaptations and yield potential of groundnut following optimum plant density and time of weeding.

## 2. Materials and methods

### 2.1. Study site, soil and weather condition

The study was carried out at the Agronomy Field Laboratory, Bangladesh Agricultural Universiry, Mymensingh, Bangladesh. The experimental site belongs to the Sonatola Soil Series of Old Brahamaputra

Floodplain characterized by Non-calcarious Deark Grey Floodplain Soil (FAO, 1988). The land was medium high with sandy-loam texture having pH 5.9. The mean monthly maximum and minimum air temperature ranged from 23.94 to 33.50 and 10.70 to 25.88$^0$ C, monthly rainfall ranged from 1.06 to 57.75 cm, monthly relative humidity ranged from 67.32 to 86.77% and average monthly sunshine hour ranged from 94.1 to 224.5 hours during the experimental period (January to June).

**2.2. Experimental setup**

The variety ACC-12, popularly known as '*Jhinga Badam*' in Bangladesh was used as the test crop. The experiment consisted of two plant densities viz. i) 200,000 plants ha$^{-1}$ spaced at 30 cm x 16.7 cm ($D_1$) and ii) 400,000 plants ha$^{-1}$ spaced at 30 cm x 8.35 cm ($D_2$) and seven weed competition periods: i) No weed competition i.e. weed free throughout the growth period ($WC_0$), ii) weed competition for the first 25 DAS and thereafter weed free ($WC_1$), iii) weed competition for the first 40 DAS and thereafter weed free ($WC_2$), iv) weed competition for the first 55 DAS and thereafter weed free ($WC_3$), v) weed competition for the first 70 DAS and thereafter weed free ($WC_4$), vi) weed competition for the first 85 DAS and thereafter weed free ($WC_5$), and vii) weed competition up to harvesting ($WC_6$). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications and unit plot size was 4 m x 2.5 m.

**2.3. Plant growth, grain yield and quality**

The land was prepared by ploughing followed by laddering to bring a good tilth. Fertilizers were applied @ 75, 200, 85 and 110 kg ha$^{-1}$ urea, triple super phosphate, muriate of potash and gypsum, respectively. One-half of total urea and entire amount of other fertilizers were applied at final land preparation. The remaining amount of urea was applied at 40 DAS as top dressing. Before sowing the pods were sun dried and shelling was done manually with much care so that the 'niacin' content of the seed remained intact. Two shelled seeds were sown per hill according to treatment specification. The crop was thinned to maintain a desired population density at 35 days after emergence. Weeding was done as per treatment specification. After the specific weed competition periods, weeds were uprooted by hand with '*Nirani*' and thereafter the crop was kept weed free up to harvest. Intercultural operations were done as necessary. Weeds were sampled from 1sq. meter from three places of each unit plot and counted species-wise at different weed competition periods. The weeds species were dried at 75±5$^0$C for 48 hours and weighed. The intensity of weed infestation (IWI) and relative density of weed (RDW) were computed by using the following formula (Mian and Rahman, 1968).

$$\text{Intensity of weed infestation (IWI)} = \frac{\text{No. of weed stands per unit area}}{\text{No. of crop hills per unit area}}$$

$$\text{Relative density of weed (RDW)} = \frac{\text{Total No. of a weed species}}{\text{Total No. of all weed species}}$$

The sample plants uprooted at maturity stage for recording data on different plant characteristics. Both pod and haulm were sun dried and recorded yield. Protein and oil contents of shelled nuts were determined through chemical analysis by Micro Jeldhal method and Soxhlet Analytical method, respectively (Hamilton and Simpson, 1967).

**2.4. Statistical analysis**

The recorded data were analysed using Analysis of variance with the help of computer package MSTAT. The mean differences among the treatments were adjusted with Duncan's Multiple Range Test (Gomez and Gomez, 1984).

**3. Results and discussion**

**3.1. Weed infestation**

The infesting species of weeds with their absolute density, relative density and intensity of infestation have been presented in Table 1. Nineteen species of weeds representing 10 families were found to grow and their population density was 150 plants m$^{-2}$. Six species belonged to the family Gramineae, two each of Cyperace, Euphorbiaceae, Solanaceae, Commelinaceae and one of Chenopodiaceae, Compositae, Amaranthaceae, Leguminosae and Convolvulaceae. The major infesting species of weeds were *Cyperus rotundus* L. (Mutha),

*Chenopodium album* L. (Bathua), *Physalis heterophylla* L. (Foska begun), *Gnaphalium luteo-album* L. (Shwetomuli) and *Paspalum disticum* L. (Knot grass) which constituted about 84.66% of the total weed population. *Cyperus rotundus* alone shared the maximum of total weed vegetation (57%) having 85.5 plants $m^{-2}$ area. This group of weeds showed the highest intensity of infestation (4.24) in which *Cyperus rotundus* L. (Mutha) alone shared the maximum part (2.85). The second group of infesting weed species were *Dactyloctenium aegyptium*, *Echinochloa colonum*, and *Cynodon dactylon* which constituted about 11% of the total weed population and their combined intensity of infestation was lower (0.58) compared to major group. The minor groups of infesting weed species were *Euphorbia hirta*, *E. microphylla*, *Alteranthera sessilis*, *Vicia sativa*, *Cyperus michelianus*, *Commelina bengalensis*, *Cyanotis axillaries*, *Echinochloa cruss-galli*, *Leersia hexandra*, *Solanum torvum* and *Ipomea aquatica* constituting about 4.34% of the total weed vegetation. This group collectively showed the lowest intensity of infestation (0.18) compared to aforementioned two groups. Intensity of weed infestation was higher when plant density was 200,000 plants $ha^{-1}$ compared to 400,000 plants $ha^{-1}$. Due to less plant density, weed received more nutrients, air, water, light and space resulting vigorous growth of weeds and ultimately infestation was more. It is reported that wide spacing arrangement supported wider canopy sizes and more growth as a result of more available space compared to closely spaced crop (Ahmed et al., 2011; Kolanl et al., 2013). Close spacing resulted in canopy closure, consistent with the findings of Tillman et al. (2006).

**Table 1**
Weed species, their absolute density, relative density and intensity of infestation.

| Local name | Scientific name | Family | Absolute density weeds (no. $m^{-2}$) | Relative density of weed (%) | Intensity of weed infestation at plant density ($ha^{-1}$) | | |
|---|---|---|---|---|---|---|---|
| | | | | | 200000 | 400000 | Mean |
| Mutah | *Cyperus rotundus* L. | Cyperace | 85.50 | 57.00 | 3.820 | 1.880 | 2.850 |
| Bathua | *Chenopodium album* L. | Chenopodiaceae | 14.10 | 9.40 | 0.640 | 0.300 | 0.470 |
| Foska begun | *Physalis heterophylla* L. | Solanaceae | 10.40 | 6.93 | 0.490 | 0.210 | 0.350 |
| Shwetamuli | *Gnapohalium luteo-album* | Compositae | 9.50 | 6.33 | 0.470 | 0.170 | 0.320 |
| Knot grass | *Paspalum distichum* L. | Gramineae | 7.50 | 5.00 | 0.350 | 0.150 | 0.250 |
| Kakpaya grass | *Dactyloctenium aegyptium* | Gramineae | 7.25 | 4.83 | 0.350 | 0.130 | 0.240 |
| Khudey shama | *Echinochloa colonum* | Gramineae | 5.10 | 3.40 | 0.230 | 0.110 | 0.170 |
| Durba | *Cynodon dactylon* | Gramineae | 4.15 | 2.77 | 0.270 | 0.070 | 0.170 |
| Bara dudhia | *Euphorbia hirta* | Euphorbiaceae | 1.00 | 0.67 | 0.040 | 0.020 | 0.030 |
| Chotto dudhia | *E. microphylla* | Euphorbiaceae | 1.00 | 0.67 | 0.035 | 0.025 | 0.030 |
| Chanchi | *Alternaria sessilis* | Amaranthaceae | 0.60 | 0.40 | 0.040 | 0.000 | 0.020 |
| Ban masur | *Vicia sativa* | Leguminosae | 0.60 | 0.40 | 0.035 | 0.005 | 0.020 |
| Nakphulle | *Cyperus michelianus* L. | Cyperaceae | 0.60 | 0.40 | 0.020 | 0.020 | 0.020 |
| Kanaibashi | *Commelina bengalensis* | Commelinaceae | 0.50 | 0.33 | 0.024 | 0.010 | 0.017 |
| Kanainala | *Cyanotis axillaris* | Commelinaceae | 0.50 | 0.33 | 0.020 | 0.014 | 0.017 |
| Shama | *Echinochloa crus-galli* | Gramineae | 0.50 | 0.33 | 0.024 | 0.010 | 0.017 |
| Araila | *Leersia hexandra* | Gramineae | 0.40 | 0.27 | 0.016 | 0.010 | 0.013 |
| Tita begun | *Solanum torvum* | Solanaceae | 0.40 | 0.27 | 0.016 | 0.010 | 0.013 |
| Kalmi shak | *Ipomoea aquatica* | Convolvulaceae | 0.40 | 0.27 | 0.020 | 0.006 | 0.013 |
| Total | | | 150 | 100 | 6.850 | 3.150 | 5.000 |

### 3.2. Dry matter production

Weed dry weight was significantly influenced by plant density and weed competition period (Table 2). It was higher at a density of 200000 plants compared to 400000 plants $ha^{-1}$ and it indicated that lower plant density encouraged luxuriant weed growth and higher plant density suppressed weed growth. A decrease in row spacing often results in decreased weed biomass (Putnam et al., 1992; Teich et al., 1993; Murphy et al., 1996) and higher yields (Putnam et al., 1992; Murphy et al., 1996), but in some cases there is no effect on yield (Vander Vorst et al., 1983; Teich et al., 1993). Increasing crop density usually results in decreased weed biomass (Samuel and Guest, 1990; Blackshaw, 1993; Murphy et al., 1996; Doll, 1997). Weed free environment increased dry matter production in groundnut (Singh and Giri, 200; Pandian and Nambi, 2002).

On the other hand, weed dry weight was progressively increased with increasing weed competition period and it was the highest in unweeded plot ($WC_6$). The results indicated that growth and development of weeds could be luxuriant throughout the life cycle of the crop. Tewari et al. (1989) observed that weed dry weight was increased markedly due to weed competition up to 8 weeks after sowing and thereafter increase was identical. The authors suggested that weeding up to 8 weeks after sowing was necessary and economic. In interaction, it was observed that in a particular plant density weed dry matter production was progressively increased with the increase of weed competition period (Table 2). The highest value (55.08g $m^{-2}$) was observed at lower density of 200,000 plants $ha^{-1}$ ($D_1$) under unweeded condition ($WC_6$) and the lowest (7.70g $m^{-2}$) was in weed competition up to 25 DAS in both plant densities ($D_1$ and $D_2$). Weed competition period up to 55 DAS exhibited similar trend in producing weed dry matter and after that it showed significant decrease due to plant densities. Weed dry matter production at that time was markedly reduced in $D_2$ as compared to $D_1$. The smothering effect of groundnut plants at higher plant densities on weeds was probably responsible for this reduction.

**Table 2**
Weed dry weight (g $m^{-2}$) as affected by plant density, weeds competition period and interaction between them, same letter in the same column and row (density mean) indicates no significantly different ($p<0.05$) as determined by the Duncan`s test.

| Plant density ($ha^{-1}$) | Weed competition period (Days after sowing) | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|
| | Weed free | 25 | 40 | 55 | 70 | 85 | 160 (Up to harvest) | |
| $D_1$(200000) | 0 | 7.70f | 21.33e | 35.66d | 43.48bc | 47.19b | 55.08a | 30.63a |
| $D_2$(400000) | 0 | 7.12f | 24.40e | 32.42d | 35.99d | 41.29c | 46.73b | 26.85b |
| Mean | 0 | 7.41f | 22.87e | 34.04d | 39.47c | 44.24b | 50.90a | |

It was also observed that weed dry matter was rapidly increased up to 55 DAS (Fig. 1). This indicated that critical period of weed competition appeared to lie between zero to 55 DAS. Banyikwa and Rulangaranga (1987) reported that weeds should be removed from groundnut field before the critical period of 42 days after emergence for highest yield. So weeding at proper time is one of the most important operations to increase the yield of groundnut.

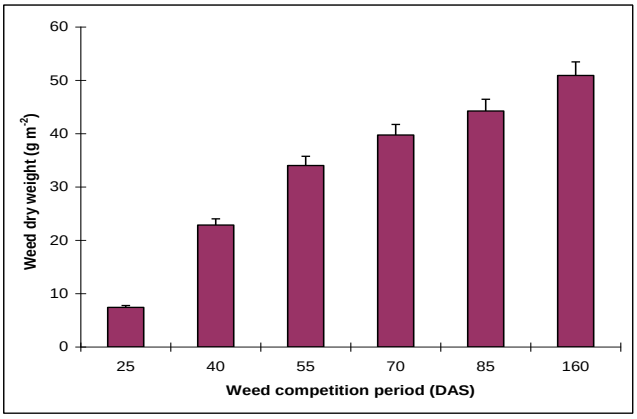


**Fig. 1.** Increasing pattern of weed dry weight with increasing weed competition period of groundnut. Data are expressed as means ± SE (n=3).

### 3.3. Pod yield

Pod yield was significantly affected by the plant density and weed competition period. In general, a density of 200000 plants $ha^{-1}$ gave the relatively low pod yield compared to a density of 400000 plants $ha^{-1}$ but decreasing pattern in pod yield due to various weed competition period was more or less similar (Fig. 2). There are reports that increase in plant density increases the pod yield in groundnut (Laurence, 1983; Salem et al., 1984; Tagsina et al., 1989; Jadho et al., 1992; Kumar, 1993; Nakagawa et al., 1996). Higher plant population did not always encourage producing more primary branches and total pods $plant^{-1}$ than lower plant population, ultimately photosynthetic products distributed well and accumulated in the pod. So shelling percentage, fresh and dry haulm yield and also pod yield were high at high plant density. Luxuriant growth of weed in lower density of crop compared to high density competed more for air, nutrients, water, space, light and as was reflected in the increased dry weight of weeds resulted in corresponding decrease in pod yield.

It was observed that weed competition period from zero to 40 DAS and thereafter weed free up to crop harvest gave the highest pod yield (Fig. 2). Further increase in the duration of weed competition period resulted in the decrease in pod yield and became the lowest in the unweeded treatment. This was in conformity with the findings of Singh et al. (1985) who found that it is essential to keep the groundnut crop weed free for the first 55 DAS and weed emerged after that period did not affect its yield. The pod yields were highest when weed free conditions were maintained up to 42 DAS (Banyikawa and Rulangaranga, 1987), 45 DAS Naidu et al. (1985), 50 DAS (Kaul and Das, 1986). Sibuga et al. (1989) reported that weed infestation for the first 6 weeks reduced yield by 46% for cv. MGC81, 47% for cv. MGV96 and 55% for cv. MM compared with weed free plots. The best results were obtained by N'Zala et al. (2002) when the weeding period took place before and shortly after flowering (from the third week after emergence and the part of the vegetative cycle that corresponds to the first 35 days. The effects of various weedy intervals on peanut yield were also investigated by Everman et al. (2008) and they observed that the critical period of grass weed control was found to be from 4.3 to 9 wk after planting (WAP), whereas the critical period of broadleaf weed control was from 2.6 to 8 WAP. It was observed that weed competition period up to 40 DAS with a density of 400000 plants $ha^{-1}$ gave the highest pod yield (Fig. 2). Wesley et al. (2008) reported that the critical period of grass weed control was found to be from 4 to 9 weeks after planting whereas, the critical period of broad leaved weeds control was from 2 to 8 weeks. It is important to remove weeds in groundnut at 15, 30, 45, 60 days after sowing and up to maturity to maximize yield and net returns (Nambi and Sundari, 2008). It was evident that in the unweeded treatment where density was very high and the weed plants competed with the crop for the space, air, moisture, nutrients and light and the resultant effect was the lowest pod yield.

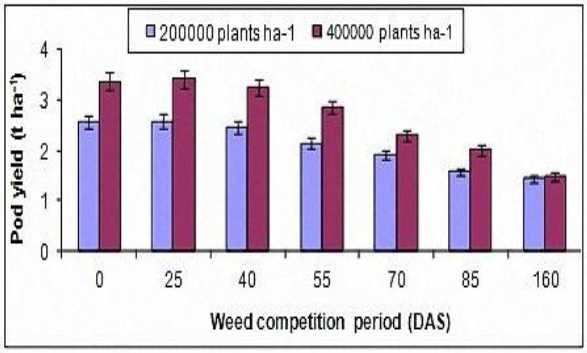


**Fig. 2.** Effect of plant density and weed competition period on pod yield of groundnut. Data are expressed as means ± SE (n=3).

### 3.4. Correlation between pod yield and weed dry matter production

The pod yield was found to have a significant negative correlation (r = -0.935) with weed dry matter production (Fig. 3). It was observed that as weed dry matter production was increased, the yield of pods was found to decrease with increasing weed competition period in both plant densities included in the study. Weed growth was luxuriant at lower density reflected in the increased dry weight of weeds resulted in the corresponding decrease in pod yield. Currey and Hopper (1979) observed that yield reduction of groundnut was more strongly

correlated with stem density than weed dry weight. Therefore, an increase in the dry matter production will lead to a decrease in the yield of pods.

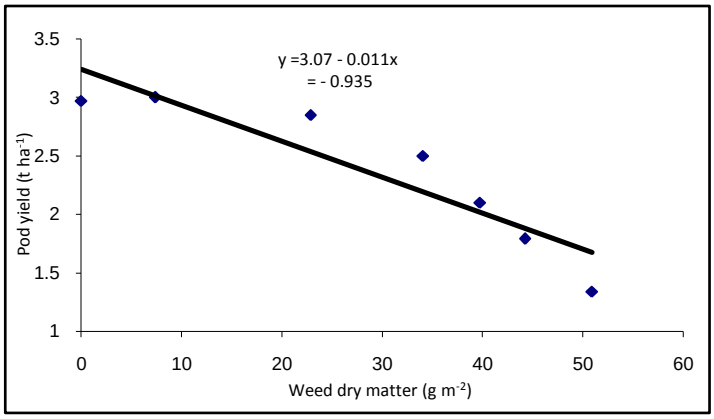


**Fig. 3.** Correlation between pod yield and weed dry matter production of groundnut.

### 3.5. Seed quality

Seed quality expressed through protein and oil contents showed that plant population did not influence any of the quality significantly but 200,000 plants $ha^{-1}$ performed better than 400,000 plants $ha^{-1}$ (Table 3). These findings were also in agreement with the results of Saini et al. (1971), Savy and Canecchio (1975) and Alam et al. (2002). Both protein and oil content affected significantly by the weed competition periods and these quality traits decreased gradually with increasing weed infestation period. However, the highest protein (25.11%) and oil content (47.98%) were recorded at weed free treatments which were statistically identical up to 55 DAS and the lowest were recorded at unweeded treatment (Table 3).

**Table 3**
Effect of plant population and weed competition period on protein and oil content of groundnut. Means followed by the same letter within each column are not significantly different at the ($p<0.05$) as determined by the Duncan`s test.

| Treatments | | Protein content | Oil content |
|---|---|---|---|
| Plant population (Plants $ha^{-1}$) | $D_1$(200000) | 25.12a | 47.97a |
| | $D_2$(400000) | 24.98a | 47.80a |
| Weed competition period (DAS) | $WC_0$ | 25.11a | 47.98a |
| | $WC_1$ | 25.10a | 47.95a |
| | $WC_2$ | 25.02a | 47.86a |
| | $WC_3$ | 24.85ab | 47.54ab |
| | $WC_4$ | 24.36c | 46.88c |
| | $WC_5$ | 24.12cd | 46.48cd |
| | $WC_6$ | 23.56e | 45.80e |

Inspection on data on seed quality revealed a significant effect by the interaction of plant population and weed infestation periods. Under low plant population both protein and oil content decreased gradually with increasing weed infestation period but under high plant population as well as increasing infestation period from 40 DAS both protein and oil content differed showing irregularity in trends (Table 4). A possible explanation of reverse trend under high plant population is that after pegging of pods; microclimate below the soil surface might be, acted upon normal flourishment of quality attributes. These results are in partial agreement with the findings of Kumar and Venkatachari (1971) who found higher percentage of protein and oil content with lower plant population. Weed free period up to 40 DAS with combination of both low and high plant density produced statistically high quality of groundnut seed in respect of protein and oil content However, our result suggest that

weed free period up to 40 DAS with combination 4000000 plant $ha^{-1}$ density should be maintained for getting both maximum yield and high quality seed.

**Table 4**
Interaction effect of plant population and weed competition period on protein and oil content of groundnut. Means followed by the same letter within each column are not significantly different at the ($p<0.05$) as determined by the Duncan`s test.

| Treatments (Plant population x weed competition period) | | Protein content | Oil content |
|---|---|---|---|
| 200,000 (Plants $ha^{-1}$) $D_1$ | $WC_0$ | 25.61a | 48.07a |
| | $WC_1$ | 25.57a | 48.07a |
| | $WC_2$ | 25.53a | 48.01a |
| | $WC_3$ | 25.43a | 47.93a |
| | $WC_4$ | 25.03b | 47.83ab |
| | $WC_5$ | 24.51bc | 47.82ab |
| | $WC_6$ | 24.42c | 47.60ab |
| 400,000 (Plants $ha^{-1}$) $D_2$ | $WC_0$ | 25.41a | 47.99a |
| | $WC_1$ | 25.39a | 47.85a |
| | $WC_2$ | 25.01b | 47.66ab |
| | $WC_3$ | 24.85bc | 47.54b |
| | $WC_4$ | 24.59bc | 46.88c |
| | $WC_5$ | 24.32c | 46.80c |
| | $WC_6$ | 24.35c | 46.95c |

## 4. Conclusion

Plant density and weed competition period emerged out as two important determinants of intensity of weed infestation, weed dry matter production and yield of groundnut. *Cyperus rotundus* alone shared the maximum of total weed vegetation (57%) having 85.5 plants $m^{-2}$ area and showed the highest intensity of infestation (2.85) and the minimum infestation was at 400000 plants $ha^{-1}$. The results further pointed out that 400000 plants $ha^{-1}$ with weed free period for the first 40 DAS emerged out as a promising management practices for the improvement of pod yield and good quality seed. It should be postulated that shoot competition for light is most important when groundnut is infested with weeds, and if good yield is to be obtained, weeds should be removed farm before the critical period of 40 days after emergence.

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