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Syed Abul Hassan Hussainy
Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Vaidyanathan R
Professor and Head, Oilseeds Research Station, Tamil Nadu Agricultural University, Tindivanam, Tamil Nadu, India

Correspondence
Vaidyanathan R
Professor and Head, Oilseeds Research Station, Tamil Nadu Agricultural University, Tindivanam, Tamil Nadu, India

Potential yield of groundnut (*Arachis hypogaea*) based intercropping system as influenced by different irrigation regimes

Syed Abul Hassan Hussainy and Vaidyanathan R

Abstract
A field trial was conducted during *kharif* season of 2017 and 2018 to study the Potential yield of groundnut (*Arachis hypogaea*) based intercropping system as influenced by different irrigation regimes. Groundnut intercropped with blackgram resulted higher in number of branches/plant (7.18) with increased crop growth rate and relative crop growth rate during the stages of growth. Irrigation scheduling of IW/CPE ratio 0.75 significantly improved the growth of groundnut crop with higher number of branches/plant (7.08), increased CGR and RGR throughout the crop growth. Number of pods/plant of 12.7 were recorded under groundnut blackgram combination with haulm yield of 4010 kg/ha and was followed by sole crop of groundnut. Lower yield gap of 35.7% was observed in groundnut + pearlmillet combination. IW/CPE ratio 0.75 resulted least in yield gap by 34.1% in comparison to the other Irrigation scheduling. From the study, groundnut + blackgram intercropping system with irrigation scheduling at 0.75 IW/CPE ratio enhances the growth and yield of the system.

Keywords: Groundnut intercropping, Irrigation scheduling, Root: Shoot ratio, Oil content, Percent yield gap

Introduction
Groundnut (*Arachis hypogaea* L.) is an oil seed crop from the family of Leguminosae, originated from South America. It is grown in the tropical and sub tropical regions of the world and commonly known as poor man's almond (or) wonder nut.

Cultivation of groundnut along with other crops (as intercrop) provides greater stability with higher system productivity in unit area and time as the cultivation of sole crop is highly vulnerable to weather conditions resulting in reduction in yield and economic losses. In a cropping system, compatibility is the key factor where both the crops mutually benefited. Hence, selection of crops with less competition for radiation, CO_2, nutrients, soil moisture and space etc., is essential for success of the system (Natarajan and Willey, 1986) [7].

Proper utilisation of water is essential, as the water scarcity nowadays has increased due to industrialisation, intensive agriculture and climate change. In groundnut, irrigation at critical growth stages and irrigation based on the crop evapotranspiration results in improved water use efficiency (Ibrahim *et. al.,* 2002) [3]. The major challenge in the intercropping system is scheduling of irrigation as the consumptive water use is differ between the crops.

Hence, the present study is planned to determine the production potential of groundnut based intercropping system and to find suitable climatological irrigation schedule for the North-eastern state of Tamil Nadu to increase system productivity along with higher monetary returns with minimal water usage.

Materials and Methods
Field trial was conducted during the year 2017 and 2018 (Kharif season) at Oilseeds Research Station, Tindivanam, Tamil Nadu, India. The farm is situated in North eastern part of Tamil Nadu with latitude and longitude of 12º21.2290´ N and 79º66.93838´ E at MSL of 45.6 m. The soil of the experimental field was belongs to sandy loam (20.4% course sand, 30.6% fine sand, 26.2% silt and 22.6% clay) in texture, neutral in reaction, medium in organic carbon (0.56%). The nutrient status of the soil was low in available nitrogen (246 kg/ha), medium in phosphorus (24.1 kg/ha) and potassium (204 kg/ha). The mean maximum and minimum temperature of the location during 2017 and 2018 were 32.4 ^{0}C, 24.9 ^{0}C and 35.3 ^{0}C, 26.4 ^{0}C respectively.

During both the years, occurrence of rainfall in the experimental location was abnormal and lost as runoff. The cropping period recorded mean annual rainfall of 11.5 mm, 973.1 mm and mean evaporation of 5.8 mm, 6.15 mm during 2017 and 2018.

The trial was laid out in split plot design with three replications. The treatments in the main plot includes five intercropping system *viz.*, sole groundnut, groundnut + castor (6:1), groundnut + blackgram (6:1), groundnut + sesame (4:1) and groundnut + pearl millet (4:1) and three sub plots with IW/CPE ratio of 0.50, 0.75 and 1.0. The plant population maintained in the intercropping system of groundnut with castor was 7,936 plants/ha and blackgram population of 47,619 plants/ha. The total plant population of 285,714 plants/ha was maintained. In another intercropping system, groundnut with sesame, pearl millet maintained population of 22,222 plants/ha and 29,630 plants/ha with total population of 266,666 plants/ha. The recommended dose of fertilizer (25:50:75 kg NPK) for groundnut was applied in splits. 50% of nitrogen, potassium and 100 % phosphorous applied as basal and remaining 50% dose of nitrogen and potassium was applied during 45 days after sowing along with gypsum @ 400 kg/ha. Irrigation was applied based on IW/CPE ratio and measured with an 18-inch cutthroat flume. The total consumptive use and soil moisture extraction pattern of the crop was determined from the soil samples collected at different depth of 0 – 15cm, 15 – 30cm and 30 – 45cm, 45 – 60cm and 60 – 75cm.

At maturity, groundnut crop from each individual plots were uprooted and the pods were removed manually and sun dried. The dried pods were cleaned and net plot yield was weighed and expressed as kg/ha. The intercrops were also harvested at physiological maturity as per standard procedure. Percent yield gap was estimated between the potential yield and actual yield and was expressed as percentage.

$$\text{Percent yield gap (\%)} = \frac{(\text{Estimated yield} - \text{Actual yield})}{\text{Estimated yield}} \times 100$$

Where, estimated yield was calculated using the yield components. Nuclear Magnetic Resonance Spectrometer (NMRS) was used to analyse the oil content in groundnut kernels and were expressed as percentage.

Statistical analysis of variance (ANOVA) was done using SAS/STAT software (SAS Institute, 1999). The analysis of the data for the years was done separately and the Artlett's Chi-square test was used to test the homogeneity of variances. Heterogeneous variances were applied with Aitken's square root transformation and were pooled using the PROC GLM procedure considering the years as fixed effects. Critical difference (CD) at 5% level of probability and P values were used to examine differences among the treatment means.

Result and Discussion

Plant growth

The growth of groundnut was significantly influenced by the intercropping system. Groundnut intercropped with recorded superior in number of branches per plant (7.18) and was on par with sole groundnut (7.03). The crop growth rate (CGR) and relative crop growth rate (RGR) from 30 DAS to 90 DAS indicated the growth increase in dry matter of the crop through a course of time. Groundnut at 30 – 60 DAS showed higher in the growth phase due to increased dry matter accumulation of the crop and periodically decreased as the crop attained maturity due to photosynthate partitioning to the sink. Groundnut intercropped with blackgram recorded higher CGR on 30 – 60 DAS (20.1 g/m^2/day) and 60 – 90 DAS (12.6 g/m^2/day) with an average of 16.3 g/m^2/day. Lower CGR was noticed in groundnut intercropped with pearlmillet (14.9; 6.9; 10.9 g/m^2/day respectively on 30 – 60 DAS, 60 – 90 DAS and average CGR throughout the growth phase). The decrease in CGR under pearlmillet intercropping could have been due to the inhibition of the root growth in groundnut crop when intercropped with pearlmillet having greater spreading pattern in the adjacent rows leading to intermingling of roots throughout the growth eventually leading to suppressed performance of groundnut. This is in close conformity to the findings of Gregory and Reddy (1982) [2].

The same trend was seen in relative growth rate where intercropping with blackgram resulted in higher accumulation. The increase in the number of branches per plant along with higher CGR and RGR and this increase could be due to better compatibility with the legume crop as a result of lesser root competition. Shorter life span and plant height of blackgram resulted in lesser shading effect on groundnut crop throughout its growth boosting yields. Similar observations were reported by Nambiar *et al.* (1983) [6].

Irrigation scheduling with IW/CPE ratio 0.75 was found to be superior over other frequencies of irrigation. The increase can be attributed to the optimum level of irrigation supplied to the crop throughout the growth period of the crop facilitating better and proper utilisation of nutrients. The results are similar to the findings of Lokhande *et al.*, (2018) [5].

Root shoot ratio was not significantly influenced by the intercropping system rather the levels of irrigation played a vital role in defining the increase in the higher root biomass than the shoot. The decreased supply of water to the IW/CPE 0.50 plots lead to deeper root system as a result of diverted photosynthate energy in search of water. The same was seen in the water distribution pattern. The results are in concordance to the results of Behera *et al.* (2015) [1]. Germination percentage determines the compatibility between the two crops in an intercropping system. Germination percentage of groundnut was not significantly influenced by the intercropping system.

Yield attributes and yield

The yield potential of groundnut crop is determined by the yield components. Higher number of pods per plant of 12.7 was recorded under groundnut blackgram intercropping system and was followed by sole groundnut (12.4). Similarly, higher haulm yield was recorded under groundnut + blackgram (4010 kg/ha) combination proving advantageous over the other cropping systems.

Irrigation scheduling of IW/CPE ratio 0.75 recorded higher number of pods (11.3) haulm yield (3822 kg/ha). The increased performance might have been a result of adequate soil moisture content due to optimum irrigation frequency throughout the period of crop growth facilitating better nutrient uptake leading to better source sink partitioning. This is in concordance to the findings of Singh and Singh (2016) [8]. Harvest index and oil content were not significantly affected by the intercropping system as well as irrigation scheduling.

Percent yield gap

Higher percent yield gap was noted in sole groundnut (43.2%) and was followed by groundnut intercropped with blackgram

(41.3%). Lower values were observed in groundnut + pearlmillet combination (35.7). Estimated yield was calculated using the yield attributes and increased yield attributes were exhibited due to higher performance of crop. Similarly percent yield gap showed the effective conversion of yield components to yield of the crop.

Irrigation scheduling of IW/CPE ratio 0.75 effectively converted the yield attributes to the yield of the crop which could be attributed to the optimized quantity of water made available to the crop which resulted in conversion of photo assimilates to the sink increasing the yield of the crop. The results are in similarity to the observations of Kumar *et al.*, 2013 [4].

Table 1: Effect of intercropping system and irrigation scheduling on germination percentage, branches/plant, CGR and RGR of groundnut (pooled data of 2 years)

Treatments	Germination (%)	Branches/plant (No.)	CGR (g/m^2/day)			RGR (mg/g/day)		
			30 – 60	60 – 90	Mean	30 – 60	60 – 90	Mean
Intercropping								
C_1: Sole Groundnut	84.7	7.03	19.0	11.0	14.9	42.6	11.6	27.0
C_2: Groundnut + Castor	86.5	6.56	16.2	8.09	12.2	41.9	10.1	26.0
C_3: Groundnut + Blackgram	83.7	7.18	20.1	12.6	16.3	43.0	12.4	27.7
C_4: Groundnut + Sesame	85.7	6.83	17.6	9.71	13.6	42.3	11.1	26.7
C_5: Groundnut + Pearlmillet	83.2	6.37	14.9	6.85	10.9	41.2	9.44	25.3
Sem ±	1.44	0.10	0.53	0.62	0.58	0.19	0.35	0.26
CD (P=0.05)	NS	0.31	1.74	2.03	1.88	0.62	1.15	0.85
Irrigation scheduling								
I_1: IW/CPE 0.50	84.3	6.50	15.3	8.1	11.7	40.9	10.6	25.7
I_2: IW/CPE 0.75	84.6	7.08	19.5	11.1	15.3	43.1	11.4	27.3
I_3: IW/CPE 1.00	85.4	6.80	17.9	9.7	13.8	42.4	10.9	26.6
Sem ±	0.83	0.10	0.67	0.60	0.63	0.31	0.28	0.27
CD (P=0.05)	NS	0.29	1.99	1.78	1.87	0.91	0.82	0.80

Table 2: Effect of intercropping system and irrigation scheduling on root: shoot ratio, oil content, pods/plant, haulm yield, harvest index and potential yield gap of groundnut (pooled data of 2 years)

Treatments	Root: Shoot ratio	Oil content (%)	Pods/plant (No.)	Haulm yield (kg/ha)	Harvest index	Yield gap (%)
Intercropping						
C_1: Sole Groundnut	0.121	50.2	12.4	4322	0.316	43.2
C_2: Groundnut + Castor	0.122	49.9	9.53	3324	0.323	36.3
C_3: Groundnut + Blackgram	0.121	49.8	12.7	4010	0.321	41.3
C_4: Groundnut + Sesame	0.120	50.0	10.5	3253	0.322	35.9
C_5: Groundnut + Pearlmillet	0.121	49.9	8.33	2764	0.324	35.7
Sem ±	0.0004	0.05	0.52	153	0.001	-
CD (P=0.05)	NS	NS	1.69	499	NS	-
Irrigation scheduling						
I_1: IW/CPE 0.50	0.125	50.0	10.0	3109	0.319	45.2
I_2: IW/CPE 0.75	0.122	49.8	11.3	3822	0.325	34.1
I_3: IW/CPE 1.00	0.117	50.0	10.8	3672	0.320	36.1
Sem ±	0.0010	0.06	0.43	165	0.001	-
CD (P=0.05)	0.0028	NS	1.27	488	NS	-

Conclusion

From the study it can be enlightened that, groundnut intercropping with blackgram is best suited with increased growth, yield attributes and system productivity. Application of irrigation to groundnut at 14 days interval significantly improves the performance of crop with improved water use efficiency.

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