



Production potential of groundnut (*Arachis hypogaea*) based intercropping system as influenced by different levels of irrigation

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ABSTRACT

A field experiment was conducted at Oilseeds Research Station, Tindivanam during 2017–18 to evaluate the production potential of groundnut (*Arachis hypogaea* L.) based intercropping under different levels of irrigation. Groundnut when grown in intercropping systems can provide scope for improving the productivity and monetary return per unit area per unit time. As different crops have different water requirement which could be a main hurdle in intercropping system, the present study was conducted to identify the consumptive water use, water use efficiency and water productivity under intercropping system. Study revealed that, groundnut intercropped with blackgram was superior in number of nodules/plant, root depth and root volume and registered yield of 10.5% over sole crop of groundnut. Irrigation scheduling at 0.50 IW/CPE ratio recorded higher root depth and root volume but, yielded 26.5 and 18.4% lesser over IW/CPE ratio of 0.75 and 1.0, respectively. Higher net return and B: C ratio was recorded in groundnut + blackgram intercropping system with 0.75 IW/CPE ratio. The soil moisture extraction pattern varied under different intercropping systems and the frequency of irrigation. Groundnut + blackgram intercropping system utilised lesser consumptive water compared to the sole crop. Thus, from the study it may be inferred that, groundnut + blackgram intercropping system with irrigation scheduling at 0.75 IW/CPE ratio enhances the productivity with better water use efficiency and water productivity.

Key words: Consumptive water use, Intercropping, Soil moisture extraction pattern, Water productivity and use efficiency

Groundnut (*Arachis hypogaea* L.) an annual legume, belongs to the family Fabaceae native to South America. Groundnut predominantly grown under tropical and sub-tropical conditions in the world is a risky crop under dryland conditions (Murungweni *et al.* 2016) and the productivity is largely determined on the availability of rainfall received during flowering, gynophore formation and initial pod development stages as the soil moisture stress at this critical stage may lead to severe yield reductions and economic losses to the farming community discouraging further cultivation (Parmar *et al.* 2007). Aberrant weather conditions have led to decreased productivity and imbalance in the edible oil production. This shortage of oilseeds along with pulses has further aggravated malnutrition. Moreover, rapid industrialization and urbanisation has decreased the potential to increase the area under oilseed crops. Therefore, introduction of groundnut in intercropping system offers a better scope for maximizing and stabilizing the return from oilseed crops rather than cultivating as sole (Shalim-Uddin

et al. 2003).

Crop compatibility is the most essential factor for a practicable intercropping system and the success of any intercropping system depends on the appropriate selection of companion crop where, competition between them for solar radiation, CO₂, nutrients, moisture, spaces etc., is minimised (Natarajan and Willey 1986). Water is one of the crucial inputs in farming and its availability is tending to become increasingly scarce and costlier due to increased industrialisation, intensive agriculture and climate changes. Increased water use efficiency in groundnut can be possible through proper irrigation scheduling by providing only the water that matches the crop evapotranspiration and providing irrigation at critical growth stages (Ibrahim *et al.* 2002). The major constraint under intercropping system is in identifying and optimising the irrigation application as crops vary in water requirement. The foremost opportunity for increasing water use efficiency at farm level lies in understanding the irrigation scheduling for a particular agro-climatic zone in such a way that it does not compensate with the yield of both crops.

In this present study attempts were made to determine the influence of groundnut based intercropping system in the North-east State of Tamil Nadu and to identify an appropriate irrigation schedule in order to increase the productivity and

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profitability per unit water use utilised.

MATERIALS AND METHODS

A field experiment was conducted at Oilseeds Research Station (12° 21' N, 79° 66' E, and 45.6 m amsl), Tindivanam, Tamil Nadu, India during 2017–18. The soil at experimental site was sandy loam (20.4% coarse sand, 30.6% fine sand, 26.2% silt and 22.6% clay) medium in organic carbon (0.56%), low in available nitrogen (246 kg/ha), medium in phosphorus (24.1 kg/ha) and potassium (204 kg/ha). During the crop growth (June – November) of 2017 and 2018, monthly mean maximum and minimum temperature ranged between 32.4°C and 24.9°C; 35.3°C and 26.4°C respectively. The experimental site received abnormal rainfall in both the consecutive years where most of it was lost as runoff. Total rainfall received during the two seasons and the total evaporation (mean: 5.8 mm; 6.1 mm respectively throughout the crop duration) recorded during different stages of development is shown in the Fig 1.

The experiment was laid out in split plot design with 5 intercropping treatments in the main plot, viz. sole groundnut, groundnut + castor (6:1), groundnut + blackgram (6:1), groundnut + sesame (4:1) and groundnut + pearl millet (4:1) and 3 treatments in the sub plot based on climatological irrigation scheduling using IW/CPE ratio of 0.50, 0.75 and 1.0. The crops were sown under replacement series on 27 of June, 2017 and 26 June 2018, with 333333/ha plant population for sole crop of groundnut. Groundnut when intercropped with castor (7936 plants/ha) and blackgram (47619 plants/ha) retained a plant population of 285714 plants/ha and when intercropped with sesame (22222 plants/ha) and pearl millet (29630 plants/ha) retained 266666 plants/ha. Recommended fertilizer for groundnut 25:50:75 kg/ha NPK was split into 50% nitrogen and potassium with 100% phosphorus as basal and the remaining 50% of nitrogen and potassium along with gypsum (400 kg/ha) was applied to all the treatments at 45 days after sowing.

The first two irrigations were provided on the day of sowing and 5 days after sowing. The remaining irrigations were applied as per treatment based on daily pan evaporation data. Irrigation supplied to the crop was measured with an 18-inch cutthroat flume. During all the irrigations, the H_a

and H_b depths were noted and irrigation was supplied once it became constant and the time was noted using a stop watch to calculate the volume of water supplied to the plot. Buffer channels were provided around each experimental plot to prevent irrigation water from entering the adjacent plot. The soil moisture was determined using gravimetric method. The soil samples were collected using a screw auger at the depth of 0–15 cm, 15–30 cm, 30–45 cm, 45–60 cm and 60–75 cm to determine the total consumptive use and soil moisture extraction pattern of the crop as per the given formulae.

$$\text{Total consumptive use (mm)} = \sum_{i=1}^n \text{Total moisture depleted + Soil moisture contribution + ER}$$

Soil Moisture Depletion was calculated using the formula given by Dastane (1972):

$$d = \sum_{i=1}^n \frac{M_1^i - M_2^i}{100} \times \text{ASi} \times \text{Di} \times \text{ER}$$

where d, moisture deficit in the root zone; M_1^i , soil moisture in the i^{th} layer of profile 24 h after irrigation; M_2^i , soil moisture in the i^{th} layer of profile 24 h before the next irrigation; ASi, bulk density of the i^{th} layer (g/cc); Di, Depth of the i^{th} layer (cm); ER, Effective Rainfall.

Both the sole and intercrops were harvested manually, sundried and threshed manually. Groundnut was harvested on 8th October during both the years. Observations of relevant parameters of all the crops were recorded as per standard procedure. The yields of different intercrops were converted into groundnut equivalent yield based on price of the produce and expressed as kg per ha. Water use efficiency (WUE) was calculated from the amount of yield that was produced from the unit consumptive use of water (kg/ha mm).

$$\text{WUE} = \frac{\text{Equivalent yield (kg/ha)}}{\text{Total consumptive use (mm)}}$$

Similarly, Water productivity (WP) was calculated as a function of gross income to the total water used by the crop throughout its growth and expressed in ₹/ha mm.

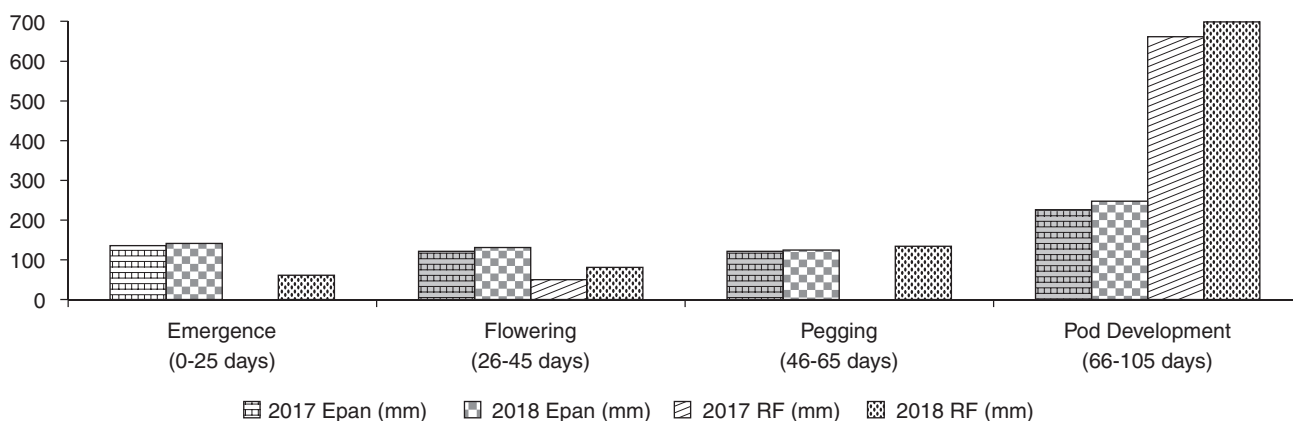


Fig 1 Evaporation and rainfall data recorded during kharif 2017 and 2018.

$$WP = \frac{\text{Gross income (₹/ha)}}{\text{Total consumptive use (mm)}}$$

Statistical Analysis of variance (ANOVA) was performed with the SAS software (SAS Institute 1999). The analysis of the data for the years was done separately and the homogeneity of variances was tested using the Bartlett's Chi-square test. The data with heterogeneous variances were applied with Aitken's square root transformation. The combined analysis was done 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.

RESULTS AND DISCUSSION

Plant growth: In groundnut, the yield depends on the basic reproductive units available, which constitutes to the flowering. Groundnut intercropped with blackgram resulted in earlier 50% flowering (43 days) and was at par with sole groundnut (43.5 days). This further affected the physiological maturity of the crop (Table 1). This may be due to the higher thermal accumulation in groundnut which could have led to earlier flowering as a result of lesser shading effect within the crops in the system. Similar results have been studied by Dapaah *et al.* (2014). The treatment with higher yield was the significance of earlier flowering and was supported by the results of Kaba *et al.* (2014) where earlier 50% flowering resulted in more number of matured nodules and yield. Irrigation scheduling based on IW/CPE ratio 0.50 recorded delayed 50% flowering may be due to the moisture stress at the initial stages of the crop growth phase.

Root parameters: Number of nodules per plant, root depth and root volume (102.5, 20.9 cm and 83.1 cm³ respectively) were recorded higher when groundnut was

intercropped with blackgram (Table 1). While, intercropping with pearl millet was inhibited (56.6, 18.0 cm and 71.0 cm³ respectively), which could have been due to the spreading pattern of pearl millet roots in the adjacent rows of groundnut crop might have intermingled throughout the growth (Gregory and Reddy 1982). Irrigation scheduling with IW/CPE ratio 0.50 recorded higher root depth and root volume (Table 1) which may be due to the inadequate availability of soil moisture which lead to increase in root growth. The number of nodules per plant depreciated enormously in response to the presence of excess water or water scarcity in the root zone. Similar findings were reported by Debasree and Gunri (2014).

Yield and equivalent yield: The maximum groundnut yield (6.62 g/plant) and equivalent yield (2081 kg/ha) was realized when intercropped with blackgram and was followed by sole groundnut (Table 2). This may be a significance of lesser light interception and the complementary effect of both the legumes which could have increased the photosynthetic efficiency with higher photosynthate accumulation eventually boosting the yield. Similar observations were recorded by Prasad *et al.* (2007). Lower groundnut yield by 17.2% and equivalent yield by 17.3% over sole groundnut was recorded under groundnut + pearl millet intercropping which could have been due to higher light interception under 4:1 row ratio along with the exhaustive nature of the C4 plant might have squeezed out nutrients suppressing the yields of companion crop. Similar results were noted by Chaudhari *et al.* (2017). Irrigation scheduling of 0.75 IW/CPE ratio recorded higher yield (6.39 g/plant) and was on par with IW/CPE ratio of 1.0 (Table 2) which might have been due to the presence of adequate soil moisture content throughout the growth period of the crop facilitating better and proper utilisation of nutrients. The results are similar to the findings of Singh

Table 1 Influence of intercropping system and irrigation scheduling on groundnut root parameters and maturity (pooled data of 2 years)

Treatment	Days to 50% flowering	No. of nodules/plant	Root depth (cm)	Root volume (cm ³)	Physiological maturity (days)
<i>Intercropping</i>					
C ₁ : Sole groundnut	43.5	90.2	20.7	81.4	103.8
C ₂ : Groundnut + Castor	45.6	76.7	18.3	72.0	106.9
C ₃ : Groundnut + Blackgram	43.0	102.5	20.9	83.1	103.5
C ₄ : Groundnut + Sesame	45.3	64.0	19.4	76.1	105.3
C ₅ : Groundnut + Pearl millet	49.2	56.6	18.0	71.0	106.8
SEm ±	0.63	4.07	0.34	1.30	0.53
CD (P=0.05)	2.05	13.3	1.12	4.24	NS
<i>Irrigation scheduling</i>					
I ₁ : IW/CPE 0.50	47.9	72.3	21.1	80.2	107.5
I ₂ : IW/CPE 0.75	44.8	85.3	19.2	77.1	105.1
I ₃ : IW/CPE 1.00	43.2	76.4	18.1	72.7	103.2
SEm ±	0.77	4.64	0.46	1.52	0.61
CD (P=0.05)	2.29	13.7	1.36	4.50	NS

Table 2 Influence of intercropping system and irrigation scheduling on groundnut yield, consumptive use, water use efficiency and water productivity (pooled data of 2 years)

Treatment	Pod yield (g/plant)	Equivalent pod yield (kg/ha)	Total consumptive use (mm)	Water use efficiency (kg/ha mm)	Water productivity (₹/ha mm)
<i>Intercropping</i>					
C ₁ : Sole groundnut	5.99	1997	504.1	3.98	228
C ₂ : Groundnut + Castor	5.55	1745	520.1	3.37	192
C ₃ : Groundnut + Blackgram	6.62	2081	497.3	4.21	241
C ₄ : Groundnut + Sesame	5.78	1808	512.1	3.55	202
C ₅ : Groundnut + Pearl millet	4.96	1652	524.4	3.17	181
SEm ±	0.13	44.2	3.01	0.11	6.29
CD (P=0.05)	0.43	145	9.82	0.36	20.6
<i>Irrigation scheduling</i>					
I ₁ : IW/CPE 0.50	5.05	1606	473.4	3.44	196
I ₂ : IW/CPE 0.75	6.39	2023	485.3	4.21	240
I ₃ : IW/CPE 1.00	5.98	1893	576.2	3.32	189
SEm ±	0.21	63.1	13.2	0.15	8.44
CD (P=0.05)	0.63	186	38.9	0.44	24.9

and Ahlawat (2011).

Water use efficiency and water productivity: Higher water use efficiency (4.21 kg/ha mm) and water productivity (241 ₹/ha) were observed under groundnut + blackgram intercropping system and was on par with sole groundnut (3.98 kg/ha mm and 228 ₹/ha mm). Similarly, application of water based on 0.75 IW/CPE ratio realised water use efficiency of 26.8% and 26.9% over 1.0 IW/CPE ratio (Table 2). This was due to the better equivalent yield from the system as a whole along with application of optimum quantity of water required throughout the crop growth. This is in accordance to the findings of Arunkumar *et al.* (2017). Groundnut can withstand heavy rainfall, and the same was noticed during both the years with negligible effect on the crop performance and yield (Khan *et al.* 2017).

Consumptive water use: Higher consumptive use of water was registered in groundnut + pearl millet intercropping system (524.4 mm equivalent to 5.24 million litres of water) and was followed by castor (Table 3). The consumptive use of water utilized by the system depended on the total biological yield produced from the system and also on the crop coefficient factor of the intercrop at different stages. Irrigation scheduling at IW/CPE ratio 1.0 recorded higher consumptive use of 21.7% over 0.50 IW/CPE ratio and

reduced as the frequency of irrigation reduced. This may be due to the frequent irrigations which could have filled the root zone of the crops with water up to field capacity very frequently leading to increased evapo-transpiration losses (Sounda *et al.* 2006).

Soil moisture extraction pattern: Soil moisture extraction pattern varied as per intercrop rooting pattern (Table 4). Sole groundnut and groundnut intercropped with blackgram utilised more amount of water from the initial 30 cm depth of soil. Groundnut intercropped with castor had a moisture extraction pattern from deeper layers up to 75 cm and was followed by pearl millet and sesame. This depended

Table 4 Influence of intercropping and irrigation scheduling on groundnut moisture extraction pattern (Mean data of 2 years)

Treatment	Soil moisture extraction pattern (%)				
	0–15 cm	15–30 cm	30–45 cm	45–60 cm	60–75 cm
<i>Intercropping</i>					
C ₁ : Sole Groundnut	25.75	23.60	20.08	16.84	13.72
C ₂ : Groundnut + Castor	25.12	23.02	20.49	17.36	14.00
C ₃ : Groundnut + Blackgram	25.66	23.68	20.09	16.84	13.73
C ₄ : Groundnut + Sesame	25.38	23.30	20.33	17.17	13.82
C ₅ : Groundnut + Pearl millet	25.20	23.20	20.47	17.26	13.87
<i>Irrigation scheduling</i>					
I ₁ : IW/CPE 0.50	25.17	23.14	20.43	17.24	14.02
I ₂ : IW/CPE 0.75	25.37	23.29	20.32	17.13	13.89
I ₃ : IW/CPE 1.00	25.73	23.65	20.14	16.91	13.58

Table 3 Influence of intercropping and irrigation scheduling on the groundnut total consumptive water use (Mean data of 2017 and 2018)

Treatment	Total consumptive use (mm)					Mean
	C ₁	C ₂	C ₃	C ₄	C ₅	
I ₁ : IW/CPE 0.50	468.5	479.5	462.2	473.2	483.5	473.4
I ₂ : IW/CPE 0.75	478.7	495.8	468.9	484.6	498.4	485.3
I ₃ : IW/CPE 1.00	565.2	585.0	560.8	578.7	591.4	576.2
Mean	504.1	520.1	497.3	512.1	524.4	511.6

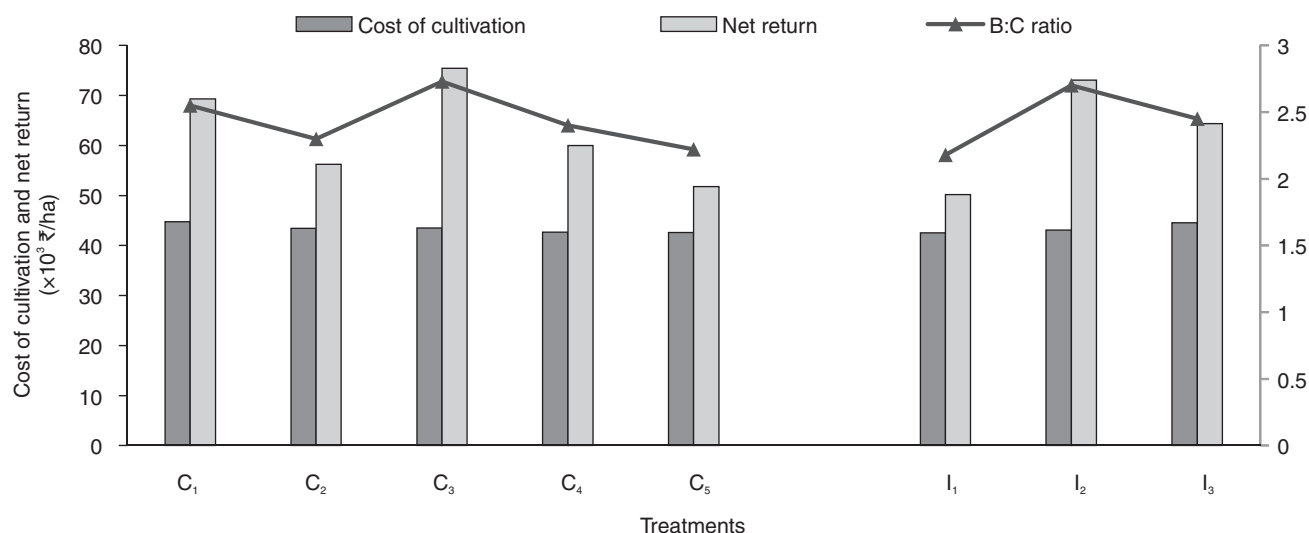


Fig 2 Influence of intercropping and irrigation scheduling on the economics of the groundnut production system (Mean data of 2 years).

on the rooting depth and rooting pattern of the intercrop. The soil moisture extraction pattern predominantly depended on the length of intermittent duration of water applied to the crop. Frequent the irrigation more was the moisture availability in the surface layer where the crop utilises with lesser root penetration. Hence, irrigation scheduling with IW/CPE ratio 1.0 made available the crop to extract more moisture from the initial 0–30 cm depth, while IW/CPE ratio of 0.50 resulted in extraction from 30–75 cm depth of the soil. Similar findings were reported by Gullati *et al.* (2001).

Economics: Higher net return (₹ 75403) and B: C ratio (2.73) was attained under groundnut + blackgram intercropping system with cost of cultivation of ₹ 43515 and was followed by sole groundnut (₹ 69306; 2.55 respectively) with cost of cultivation of ₹ 44775. Lower net return and B:C ratio was realized in groundnut + pearl millet intercropping system (₹ 51762; 2.22). Irrigation scheduling of 0.75 IW/CPE ratio recorded higher net return of ₹ 73096 and B: C ratio of 2.70 with cost of cultivation of ₹ 43101 and was followed by 1.0 IW/CPE ratio (₹ 64361; 2.45 respectively) with cost of cultivation of ₹ 44526 (Fig 2).

From the present study it can be concluded that groundnut + blackgram intercropping system is best suited when supplied with seven irrigations (excl. sowing and life irrigation) at an interval of fourteen days together can produce higher groundnut yield and equivalent yield with increased water use efficiency and water productivity eventually increasing the monetary returns from the system.

REFERENCES

- Arunkumar P, Maragatham N, Panneerselvam S, Ramanathan S P and Jeyakumar P. 2017. Water requirement of groundnut under different intercropping system and WUE in groundnut equivalent rate. *Pharma Innovation Journal* **6**(11): 322–5.
- Chaudhari D T, Vekariya P D, Vora V D, Talpada M M and Sutaria G S. 2017. Enhancing productivity of groundnut based intercropping systems under rainfed conditions of Gujarat. *Legume Research* **40**(3): 520–5.
- Dapaah H K, Mohammed I and Awuah R T. 2014. Phenological development and yield of three groundnut varieties as influenced by plant density in a forest-savanna transition zone. *International Journal of Agricultural Research* **9**(2): 87–98.
- Dastane N G. 1972. *A Practical Manual for Water Use Research in agriculture*. Navabharat Prakashan Publications, Pune, India.
- Debasree S and Gunri S K. 2014. Effect of polythene mulching, irrigation regime and fertilizer doses on summer groundnut (*Arachis hypogaea* L.) nodulation, pod yield and nitrogen availability in soil. *Environment and Ecology* **32**(4): 1301–3.
- Gregory P J and Reddy M S. 1982. Root growth in an intercrop of pearl millet/groundnut. *Field Crop Research* **5**: 241–52.
- Gullati J M L, Lenka D and Paul J C. 2001. Moisture extraction pattern, phasic water use and phasic growth in groundnut (*Arachis hypogaea*) under varying moisture regimes and ground water table condition. *Indian Journal of Agronomy* **46**(2): 287–91.
- Ibrahim A A, Stiger C, Adam H S and Adeeb A M. 2002. Water use efficiency of sorghum and groundnut under traditional and current irrigation in the Gezira scheme, Sudan. *Irrigation Science* **21**(3): 115–25.
- Kaba J S, Kumaga F K and Ofori K. 2014. Effect of flower production and time of flowering on pod yield of peanut (*Arachis hypogaea* L.) genotypes. *Journal of Agriculture and Veterinary Science* **7**(4): 44–9.
- Khan M A H, Sultana N, Akhtar S and Zaman M S. 2017. Performance of intercropping groundnut with sesame. *Bangladesh Agronomy Journal* **20**(1): 99–105.
- Murungweni C, Van Wijk M T and Smaling E M A. 2016. Climate-smart crop production in semi-arid areas through increased knowledge of varieties, environment and management factors. *Nutrient Cycling in Agroecosystems* **105**(3): 183–97.
- Natarajan M and Willey R W. 1986. The effect of water stress on yield advantages of intercropping systems. *Field Crop Research* **13**: 117–31.
- Parmar R S, Vaishnav P R, Dixit S K and Patel J S. 2007. Relationship between rainfall and groundnut productivity of Junagadh district in Gujarat State. *Journal of Agrometeorology* **9**(1): 63–7.
- Prasad T V, Nandagopal V, Gedda M V, Koradia V G and Patel H

- V. 2007. Effect of intercropping on yield and yield parameters of groundnut (*Arachis hypogaea* L.). *Indian Journal of Agricultural Sciences* **77**: 515–8.
- Shalim-Uddin M, Rahaman M J, Bagum S A, Uddin M J and Rahaman M M. 2003. Performance of Intercropping of Maize with Groundnut in Saline Area under Rainfed Condition. *Pakistan Journal of Biological Sciences* **6**: 92–4.
- Singh R J and Ahlawat I P S. 2011. Productivity, competition indices and soil fertility change of BT cotton (*Gossypium hirsutum* L.)–groundnut (*Arachis hypogaea* L.) intercropping systems using different fertility levels. *Indian Journal of Agricultural Sciences* **81**: 606–11.
- Sounda G, Mandal A, Moinuddin G and Mondal S K. 2006. Effect of irrigation and mulch on yield, consumptive use of water and water use efficiency of summer groundnut. *Journal of Crop and Weed* **2**(1): 29–32.