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Effect of genotype and plant density on growth characteristics and yield of Peanut (*Archis hypogaea*) in Iraq Effect of Genotype and Plant Density on Growth Characteristics, and Yield of Peanut (*Arachis hypogaea* L.) in Central Region of Iraq

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Abstract

This research was conducted to evaluate the effects of 17 genotypes and three plant densities (57142, 71429 and 95238 plant ha^{-1}) on growth and yield characteristics of peanut (*Arachis hypogaea* L.) in the central region of Iraq during the growing seasons of 2011- 2012. The plant densities were with the arrangement of rectangular pattern (25 x 70, 20 x 70 and 15 x 70cm. Randomized Complete Block Design with split of genotypes (sub plots) on plant densities (main plots) at three replications was investigated.

The results showed that the planting of recent released peanut cultivar have a larger seed size with further resistance to common fungal diseases known in the target area. Significant differences were noticed for plant densities, plant genotypes and their interactions for pant height, pod weight and seed oil percentage. Higher plant density exceeded in plant height and seed oil percentage. Lower plant density gave the highest pod weight. The significant difference effects of plant genotypes for branches plant-1, pods plant-1, seed pod-1, 100 seed weight and seed yield reveal that GN-IS-5 gave the lowest plant height and GN-IS-2 the highest branches plant-1 (17.07) and seed oil percentage (51.9%). Greater pod weight (17.5g) was noticed with IND-IS-14. Result indicates the wide range of pods plant-1 (38.8 - 89.3) with wide genetic base and may reflect the utilization of exploitation IDN-IS-15 in improving pods plan t^{-1} and 100 seed weight for the current released varieties by hybridization. Whereas, GN-IS-4 gave the highest seed pod-1(1.4) and IND-IS-16 exceeded significantly on all other genotypes except the released variety (IND-IS-14) and gave more than 4 ton ha^{-1}.

Keywords: Peanut; Agronomic goal; Groundnut; Soil; Genotype; Environmental factors; Crops

Introduction

Peanut or Groundnut (*Arachis hypogaea* L.) is an important oilseed crop in food legume of the America, Africa, the Indian subcontinent, Asia and Australia [1]. Peanut seed yield depends on the magnitude of management variability and practices, especially those which concerned with plant spacing, even between and/or within plants. Determining of the optimum plant population density is very important for optimal yield and presents the essential agronomic goal [2]. Sowing with the optimum seed rate will results the optimal population density and will reflects the investigating of further seed yield, reducing seed lost and costs [3]. The response of peanuts to plant density has been investigated globally, whereas, under local conditions, the optimum row and plant spacing for the current new released variety (Iraq 1, Spanish type, erect) were not established [4]. Although, planting of a larger seed size of peanut cultivars, larger seeds will cause more significant costs for planting than smaller seeds due to the test weight [5]. Two general philosophy concepts are frequently used to explain the relationship between row spacing, plant densities and yield. First, maximum yield can be obtained only if the plant community produces enough leaf area to provide maximum isolation interception during reproductive growth. Secondary equidistant spacing between plants will maximize yield because it minimizes inter plant competition and improve the sink- source and finally improve the harvest index. The optimum ecosystem which concerned plant density and planting pattern at specific location may not apply at other locations due to the regional variations in weather and soil. The further combination of the genetic concepts and field management are needed at each site to validate general recommendations [6]. Although, the greatest recorded yield for the peanut is 9.6 ton ha^{-1}, current commercial yields are 3 to 4 ton ha^{-1} in many countries and as low as 1 ton ha-1 in others [7]. Plant density and planting pattern are major cause of inability to achieve potential yield in irrigated and dry land production [8].

Previous studies indicated that that increasing plant density will increase pod and seed yield with a wide range [3, 5,9-15]. Crop growth rate, pod growth rate and pod and kernel yields have increased by the square planting pattern [16,17]. Bell et al. [1] and showed that square planting pattern produced significantly greater pod yields than the conventional commercial practice of rows apart of 90cm with rectangular pattern.

Yilmas [14] in a study on the effect of different plant densities of two peanut cultivars found that highest yield was obtained at 60 x 15cm spacing. Furthermore, Madkour et al. [18] showed that the effects of row spacing on seed and pod yields were significant of 50cm row spacing, compared to 60cm row spacing. Planting peanut in the narrow twin row pattern did not increase peanut pod yield over the standard twin row planting pattern [7]. The objective of this study was to assess the further performance of the released varieties in comparison with other promise genotypes throughout its cultivation in different plant densities and its effects on yield, its components and quality.

Material and Methods

The experiment was conducted in Ishaqi Experimental Station, Ministry of Agriculture; 45° N, 100 km north of Baghdad, Iraq, in 2011 and 2012. The soil type was clay with pH = 7.6 and electrical conductivity = 1.3 dS/m. A randomized complete block design was used with split combinations of three plant densities (main plots) and 17 plant cultivars and genotypes (sub plots) with three replications. The plant densities were 57142, 71429, and 95238 plants ha^{-1} with the arrangement of rectangular pattern (25 x 70, 20 x 70 and 15 x 70cm, respectively. Each plot size was 28m^2 (5.6 x 5m).

Uniform seeds of peanut were sown in each plot under dry conditions. According to the results of soil analysis, 200kg ha^{-1} triple super phosphate was applied before sowing. Furthermore, 60kg ha^{-1} N on sowing time and 40kg ha^{-1} after 1st hand weeding was applied. Data of plant height, branches plant-1, pod weight, pods plant^{-1}, seeds pod^{-1} and 100 seed weight were collected randomly for 20 guarded plants of each plot. Seed yield was calculated as the ratio of pod yield x shelling percentage [8]. Total seed yield for unit area was estimated by harvesting all plants of the mid two rows and converted to hectare. Estimation of oil percentage was done using Inframatic Analysis System, Perten Instruments depending on the dry weight. The data were subjected to analysis of variance and mean differences were measured by LSD [19].

Results and Discussion

Plant height (cm)

Table 1: Means of plant height and branches plant-1 of peanuts genotypes grown in different plant densities at Ishaqi Experimental Station, Iraq during 2011.

Genotype	Plant Height (cm)			Mean	Branches Plant^{-1}			Mean
	Plant Density (Plant ha^{-1})				Plant Density (Plant ha^{-1})			
	57142	71429	95238		57142	71429	95238	
GN-IS-1	50.9	51.9	67.5	56.8	10.2	10.2	11.4	10.6
GN-IS-2	45.8	55.1	59.3	53.4	15.5	18.6	16.8	17
GN-IS-3	56.1	54.6	65.8	58.7	11.6	10.5	12.1	11.4
GN-IS-4	46.5	48.6	56.9	50.7	12	12.7	10.6	11.8
GN-IS-5	47.4	41.8	60.5	49.9	11.3	10.5	10.7	10.8
GN-IS-6	67.5	58.1	68.4	64.7	10.4	11.4	11	10.9
GN-IS-7	45.1	53.1	63.3	53.8	12.5	11.3	11.3	11.7
GN-IS-8	57.9	46.5	58.7	54.4	12.2	11.3	11	11.5
IND-IS-9	44.8	57.5	63.5	55.3	12.5	10.6	10.9	11.3
IND-IS-10	62.8	69.7	70.3	67.6	12.1	11.9	11.9	12
IND IS-11	48.3	45.7	51.3	48.4	12.3	12	10.9	11.7
IND IS-12	52.1	50	57.2	53.1	10.8	13	11	11.6
IND IS-13	47.6	55.1	50.1	50.9	11.3	12	12	11.8
IND IS-14 (Iraq 1)	48.1	58.3	60.3	55.6	12.2	11.7	11.1	11.7
IND IS-15	50.8	47.7	58.6	52.4	11.3	12.4	10.1	11.2
IND IS-16	55.2	66.7	65.2	62.4	12.3	11.1	10.6	11.3
IND IS-17	55.3	58.7	58.8	57.6	11.1	16.7	10.5	12.8
Mean	51.9	54	60.9		11.9	12.2	11.4	

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LSD Plant Density† = 6.7**	NS
LSD Plant Genotype†= 8.567**	3.928*
LSD Plant Density x Genotype†= 9.65**	NS

Significant differences were noticed for plant densities, plant genotypes and their interactions (Table 1). The higher plant density exceeded significantly by higher plant height than others plant densities and agreed with Shiyam [20]. The genotype GNIS-5 gave the lowest plant height whereas IND-IS-10 showed the highest and differed significantly of all genotypes under investigation (Table 1). The IND-IS-10 which cultivated at higher plant density showed the highest plant height (70.3cm) while GNIS-5 genotype with the moderate plant density revealed the lowest plant height (41.8cm). Results reflect the effect of the genetic base diversity among the genotypes and the other environmental factors concerned with plant distribution [13].

Branches plant^{-1}

Table 1 reveals the significant difference for plant genotypes only. Higher branches plant^{-1} (17.07) was noticed with the genotype IND-IS-11 and differed significantly of all genotypes except GNIS-2. The result may disagreed with Giayetto et al. [5] and Kathirvelan & Kalaiselvan [12] for plant density influence on growth parameters of peanut and which they indicated the increase of branches plant^{-1} with wider spacing (low plant density) and results of Singh and Singh [13], when they investigated less ranges of branches plant^{-1} (3.22 – 8.13) due to the low plant spacing (45 x 15cm). Widening of row spacing allow to exploit light interception and solar energy to volunteered to more and effective photosynthesis by the plant than narrow rows spacing, in addition to reduce plant competition for all other inputs [11].

Pod weight (g)

Pod weight was highly significantly affected by planting density, plant genotypes and their interactions (Table 2). Higher and lower plant densities (15.6 and 16.0g) differed than the moderate density (13.3g) for pod weight. Greater pod weight was 17.75g for IND-IS-14 (cultivar Iraq 1, which registered and released for wide cultivation in Iraq in 2012) differed significantly (P≤0.01) with all genotypes except which have above 16.22g of pod weight. Results in Table 2 revealed that the genotype GN-IS-6 with 71429, and GN-IS-15 with 57142 plants ha^{-1} showed the lowest and highest pod weight (9.8 and 19.2g). Results agreed with Rasekh et. al. [2] and Giayetto et. al. [5] when they discussed the distribution of assimilation rate depending the origin of its production above different physiological sink for assimilation and capacity of translocation between sink and source and explain the pod weight change according the different input and management factors. Results agreed with Wright and Bell [8] when they studied the effect of plant population on peanut and suggested that with reducing plant density, pod weight and yields had increased.

Pods plant^{-1}

Table 2: Means of pod weight (g) and pods Plant^{-1} of peanuts genotypes grown in different plant densities at Ishaqi Experimental Station, Iraq during 2011.

Genotype	Pod Weight (g) Plant Density (Plant ha^{-1})			Mean	Pods Plant^{-1} Plant Density (Plant ha^{-1})			Mean
	57142	71429	95238		57142	71429	95238	
GN-IS-1	15.6	12.6	16.8	15	65.5	34.9	29.2	43.2
GN-IS-2	13.1	13.1	13.7	13.3	58.8	54.8	97.5	70.4
GN-IS-3	15.3	14.1	18.9	16.1	56.5	64.1	76.1	65.6
GN-IS-4	14.5	15.4	16.5	15.4	60	54.6	55.4	56.7
GN-IS-5	17.1	11.9	16.2	15.1	45.8	75.4	30.7	50.6
GN-IS-6	15.1	9.8	16.9	14	72.5	69.1	54.8	65.5
GN-IS-7	17.9	14.5	12.9	15.1	40.4	31.5	44.5	38.8
GN-IS-8	19	13.8	13.9	15.8	51.7	64.5	84.9	67
IND-IS-9	15	11.7	12.7	13.1	50.9	53.3	72.9	59
IND-IS-10	12.3	11.5	12.7	12.2	69.9	59.2	55.3	61.4
IND IS-11	12.9	10.6	12.8	12.1	47	57.8	53.5	52.8
IND IS-12	13.5	15.2	19.1	15.9	71.7	87.5	74.9	78
IND IS-13	12.6	11.7	14.4	12.9	58.3	75.7	84.1	72.7
IND IS-14 (Iraq 1)	18.7	15.8	18.7	17.8	90.2	41.5	76.7	69.4
IND IS-15	19.2	14.7	17.6	17.2	82.5	115.1	70.4	89.3
IND IS-16	16.7	15.6	18.4	16.9	58.9	53	62.7	58.2
IND IS-17	16.9	14	19	16.6	63.3	26.2	59.9	49.8

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Mean	15.6	13.3	16		61.4	59.9	63.7	
LSD Plant Density†= 1.94**				NS				
LSD Plant Genotype†= 2.36**				27.925**				
LSD Plant Density x Genotype†= 4.43**				NS				

Plant genotypes showed its high significant effect on pods plant^{-1}. IDN-IS-15 exceeded in pods plant^{-1} and differed significantly with all genotypes under investigation (Table 2). This result indicates the wide range of pods plant^{-1} (38.8–89.3) with wide genetic base and may reflect the utilization of exploitation IDN-IS-15 in improving this trait for the current released varieties by hybridization according to Singh and Singh [13]. Plant densities and their interactions with genotypes under investigation didn't affect the peanut pods plant^{-1} significantly (Table 2). Current results of pod Plant^{-1} may require more emphasis on measurement argumentation and disagreed with what Onat et al. [3]; Awal & Aktar [9] and Kathirvelan & Kalaiselvan [12] found in their studies.

Seed pod^{-1}

Genotypes affected significantly at P≤0.05 on seed pod^{-1}. The genotype GN-IS-4 gave the highest seed pod^{-1} (1.4) and didn't differ significantly with GN-IS-1 and GN-IS-8 only. Plant density and its interaction with genotypes didn't affect significantly the seed pod^{-1} and ranged between 1.19 and 1.25 (Table 3). In general, low seed pod^{-1} indicate the importance the genetic improvement of this trait for raising yield potential of peanut although the large seed size realized [13].

Table 3: Means of seed pod-1 and 100 seed weight (g) of peanuts genotypes grown in different plant densities at Ishaqi Experimental Station, Iraq during 2011.

Genotype	Seed Pod^{-1} Plant Density (Plant ha^{-1})			Mean	100 Seed Weight (g) Plant Density (Plant ha^{-1})			Mean
	57142	71429	95238		57142	71429	95238	
GN-IS-1	1.23	1.3	1.43	1.32	49.2	28.3	28.1	35.2
GN-IS-2	1.33	1.13	1.1	1.19	49.1	43.1	35.3	42.5
GN-IS-3	1.17	1.03	1.27	1.16	54.5	42.2	30.2	42.3
GN-IS-4	1.5	1.5	1.2	1.4	33.6	32	34.1	33.2
GN-IS-5	1.4	1.33	1.23	1.32	48	55.2	33.5	45.6
U GN-IS-6	1.1	1.3	1.2	1.2	30.8	47.3	25.9	34.7
GN-IS-7	1.23	1.07	1.2	1.17	35	28.1	24.6	29.2
GN-IS-8	1.4	1.37	1.13	1.3	52.1	38.8	38.1	43
IND-IS-9	1.13	1.1	1.1	1.11	31.7	20.3	22.3	24.8
IND-IS-10	1.3	1.17	1.13	1.2	45.8	54.2	41.5	47.2
IND IS-11	1.3	1.1	1.07	1.16	48.5	41	39.2	42.9
IND IS-12	1.37	1.17	1.13	1.22	47.2	43.3	42	44.2
IND IS-13	1.4	1.17	1.03	1.2	48.8	46.2	40.9	45.3
IND IS-14 (Iraq 1)	1	1.03	1.3	1.11	52.1	48.3	28.4	42.9
IND IS-15	1.13	1.07	1.2	1.13	47	60	51	52.9
IND IS-16	1.1	1.23	1.3	1.21	50	45.8	44.9	46.9
IND IS-17	1.13	1.3	1.17	1.2	56.5	34.8	21.8	37.7
Mean	1.25	1.2	1.19		45,9	41.7	34.2	
LSD Plant Density† NS					NS			
LSD Plant Genotype†= 0.157*					17.964**			
LSD Plant Density x Genotype† NS					NS			

100 Seed weight (g)

This trait affected significantly by cultivation of different genotypes. Higher 100 seed weight investigated with IND-IS- 15 which resulted 52.86g and differed significantly at P≤0.01 with all genotypes except IND-IS- 10, IND-IS- 16 and GN-IS-5 (Table 3). Results indicated the ability of investigating a high genetic advance for increasing seed weight by exploiting the genetic variability within genotypes and the high heritability which reflects the agreement with Singh and Singh [13]. The importance of seed weight has high phenotypic and genotypic correlation which presents the importance of the role of the genetic approaches and field management (e. g. plant density) on the close interrelationships with protein, oil and quality traits [11]. Although a wide range of 100 seed weight for the varied plant densities in this study (36.89-44.69g), there were no significant

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differences noticed among plant densities. In contradiction with that of Kathirvelan and Kalaiselvan [12]; Howlader et al. [11]; Giayetto et al. [5]; and Rasekh et al. [2] mentioned especially the harvest index.

Seed yield (kg ha^{-1})

Similar to 100 seed weight, seed yield per unit area influenced by peanuts genotypes only (Table 4). The genotype IND-IS-16 exceeded significantly on all other genotypes under investigation except IND-IS-14 and gave more than 4 tons ha^{-1}. Whereas, plant densities gave no significant differences and out yielded with a range of 2961 and 3060kg ha^{-1} (Table 4). Results concerned plant density effects on seed yield may disagreed with Rasekh et al. [2]; Giavetto et al. [5]; Kathirvelan and Kalaiselvan [12]; Howlader et al. [11]; and Shiyam [20]; Awal and Aktar [9] and El Naim et al. [10] due to the different philosophy of plant density arrangements and patterns, especially when they used square and narrow rectangular row spacing. Results dis agreed with Papastylianou [21] in obtaining maximum yield with 7-8 plants m^{-2} and yield gradually increased to a maximum with 11-14 plants m^{-2}. Results emphasize what Papastylianou [21] for yield which unaffected by further increasing plant density while at <7-8 plants m^{-2}.

Oil percentage (%)

High significant differences for plant densities, genotypes and their interaction effects were noticed on oil percentage (Table 4). Greater oil percentage was obtained with the narrow plant spacing. The plant density of 95238 plant ha^{-1} gave 49.47% and differed of the other two plant densities. The genotype GN-IS-2 gave the highest oil percentage (51.6%) and differed significantly with all genotypes which resulted less than 50.6% of oil percentage (Table 4). Plant density and genotype interaction revealed significant effect on oil percentage of peanut with a range of 46.1% – 52.9%) and reflects the extend effects of the genetic and environmental variations (field practices and management) with its interactions.

The previous results agreed with Mixon [22] that high plant density out yielded 7% more pods than low plant density and Awal and Aktar [9] which demonstrated that 20cm row spacing produced the highest seed yield; pod yields and thereafter yield decreasing gradually with widening the row spacing.

Table 4: Means seed yield (kg ha^{-1}) and Oil percentage (%) of peanuts genotypes grown in different plant densities at Ishaqi Experimental Station, Iraq during 2011.

Genotype	Seed Yield (kg ha^{-1}) Plant Density (Plant ha^{-1})			Mean	Oil Percentage (%) Plant Density (Plant ha^{-1})			Mean
	57142	71429	95238		57142	71429	95238	
GN-IS-1	4411	2800	3022	3411	51.33	49.83	49	50.06
GN-IS-2	2517	2666	2893	2692	51.77	52.1	50.9	51.59
GN-IS-3	2822	2844	2428	2698	46.97	48.6	50.57	48.71
GN-IS-4	3322	3067	3022	3137	48.27	49.3	48.7	48.76
GN-IS-5	2122	1900	2193	2072	50.8	48.07	49.9	49.59
GN-IS-6	2244	2372	2078	2231	48.3	51.4	47.6	49.1
GN-IS-7	2206	2867	2356	2476	45.3	49	49.5	47.93
GN-IS-8	3267	2756	3456	3159	50.67	48.63	50.27	49.86
IND-IS-9	1750	2394	2189	2111	49.07	48	49.6	48.89
IND-IS-10	2017	3111	2989	270	47.03	47.5	47.8	47.44
IND IS-11	3411	3122	3922	3489	47.13	46.07	47.9	47.03
IND IS-12	38.22	3544	3656	3674	52.93	49.5	50	50.81
IND IS-13	3167	3000	3211	3126	50.57	48.33	49.03	49.31
IND IS-14 (Iraq 1)	3972	3478	4006	3819	45.8	46.23	49.03	47.02
IND IS-15	2850	2700	3078	2876	47.8	48.7	50.17	48.89
IND IS-16	4300	3956	3906	4054	48.13	50.2	49.23	49.19
IND IS-17	3656	3767	3600	3674	49.4	48.1	51.77	49.76
Mean	3050	2961	3060		48.9	48.8	49.47	
LSD Plant Density† NS				0.351				
LSD Plant Genotype†= 338				1.365				
LSD Plant Density x Genotype† NS				2.395				

Conclusion

New focuses are required for studying plant distribution in the field, in addition to the emphasis on studying the other field management's factors due to the less attention with this crop in Iraq. The results of this study show that the increase of plant density didn't affect seed yield significantly. Previous researchers

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accepted distribution of assimilation between different partitions under agronomy and environment factors [1]. The urgent needs are to inspect for optimal combinations for better distribution of light in canopy, higher absorption of nutrients from soil and low competition between plants to increase photosynthesis and reflects the increasing of branches plant-1 and seeds pod-1. Crop growth which indicates the most effective of seed pod-1 of peanut is the major effective and limiting factor of seed yield which matched with [17,23-24].

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