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Effects of Inter and Intra Row Spacing on Yield and Yield Components of Erect Type Groundnut (*Arachis Hypogeal* L.) in West Hararghe Zone, Eastern Ethiopia

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Abstract: Ground nut (*Arachis hypogaea L.*) is one of important oil crop grown in Ethiopia**.** However, its productivity is low due to in appropriate intra and inters spacing practice. The study was conducted in 2019 and 2020 main cropping season at two locations for two consecutive years in west Hararghe Zone, Ethiopia; The objective of this study was to determine the optimum inter- and intra-row spacing of ground nut for maximum yield and yield components. The experiment was laid out randomized complete block design with three replications in a factorial arrangement of three inter-rows (50cm, 60cm and 70 cm) and four intra-row (10cm, 15cm, 20cm and 25 cm) spacing using groundnut Werer-962 variety. From combined mean result observed inter- and intra-row spacing significant different for days to flowering, days to maturity, plant height, number of pods per plant, grain yield. While, non-significant different showed for number of seed per pod. The maximum number of pods per plant (40.86 and 40.18) was obtained from 60cm*25cm and 60cm*20cm inter- and intra-row spacing, respectively. The highest grain yield (2722kg ha^{-1}) was obtained at interaction of 60cm * 20cm spacing, followed by (2622 $kgha^{-1}$) at 60cm*25cm inter- and intra-row spacing. While the lowest (1542 ha^{-1} and 1592 ha^{-1}) was obtained from 70cm*25cm and 70cm*20cm inter- and intra-row spacing, respectively. The optimum spacing was given 37.31% yield advantage than over control 60cm*10cm inter- and intra-row spacing. However, based on agronomic performance use of 60cm * 20cm spacing is promising for groundnut production in west Hararghe and similar agro ecologies.

Keywords: Intra-row Spacing, Groundnut, Row Spacing

1. Introduction

Groundnut (*Arachis hypogaea L.*) is an important monoecious annual legume used for oilseed, food and animal feed [14]. Ground nut is one of important oil crop grown in Ethiopia**.** However, its productivity is low due to in appropriate intra and inters spacing practice. It was probably introduced to northern Ethiopia by the Portuguese in the 17th century, and somewhat later through the Arab influence to south eastern part of the country [1]. It is the main source of food in various forms and used as a component of crop rotation in many countries [8]. It is the world's thirteenth most important food crop, fourth most important source of edible oil and the third most important source of vegetable protein [13].

The estimated production area and yield of groundnut in Ethiopia in 2019/2020 cropping season were 87,925.23ha and Oromia shared (50,121.08 ha), However, it is important to note that the national average yield of groundnut (1.71t ha^{-1}), is much lower than the average potential yield for improved groundnut varieties. Plant density and planting arrangement are efficient management tools for maximizing crop yield by optimizing resources utilization such as light, nutrients and water and reduce soil surface evaporation [3].

Production of groundnut is influenced by many factors such as climatic factors (rainfall, temperature, humidity, wind, solar radiation, edaphic), soil factors (very low organic carbon and

very low available phosphorus) and biological factors (pests and diseases) and agronomic factors (fertilizer, spacing and weed management). Plant spacing plays an important role on growth, yield and quality of groundnut. Establishment of optimum population per unit area of the field is essential to get maximum yield. If the plant population is too high, plants compete with each other for resources and low yield was realized. The relationship between plant spacing, plant densities and yield; two approaches are used commonly. First, if the plant produces enough leaf area to maximize isolation interception during reproductive growth, maximum yield can be obtained. Secondly, equidistant row spacing between plants will provide maximum yield since it will minimize inter plant competition. The highest pod number per plant was obtained from wide row spacing (75 cm row spacing) due to less competition among the plants to get enough space for their growth and development [6, 7]. The researcher stated that as the number of plants per unit area increased, competition for growth resources such as nutrients, water and light also increased. These results are in agreement with the findings of [11, 5].

Plant spacing is one of the most important factors limiting the production of groundnut in west Hararghe zone. It is important to note one of the factors leading to poor yields in most small scale farms is inappropriate plant spacing practice. Many of groundnut farmers of the zone have been faced with the problem of using the existing recommended spacing between plant and row. The use of narrow spacing between plant and row may affect the yield of groundnut. West Hararghe is the production belt for groundnut and widely grown by small scale farmers. The nature of groundnut peg development requires light soil for easy peg penetration and enough spacing for earthing up for good vegetative growth and peg development. Earthing up of groundnut where soil is piled up around the stem is important for peg formation. Generally, proper inter and intra-row spacing are imperative in the determination of yield in groundnut production. Therefore, this study was undertaken to study into inter and intra- row spacing to improve the growth and yield of groundnut west Hararghe zone.

2. Materials and Methods

2.1. Description of the Study Area

The experiment was conducted at Daro Lebu district (Mechara on station and Milkaye on FTC). Mechara is located 434 km to the East of Addis Ababa in Daro Lebu District of West Hararghe Zone in Oromia Regional State. It is 110 km from Zonal Capital city Chiro to the south on a gravel road that connects to Arsi and Bale Zones. Located at latitude 8°36'N and longitude 40°18'E. Its' altitudes is 1750 m.a.s.l. with annual average temperature and rainfall 16°C and 963 mm in the same order. The major soil type of the center is sandy loam clay which is reddish in color. Milkaye is located 38km to the east of Mechara town in Daro Lebu District of West Hararghe Zone. Located at latitude 06°69'03.8''N and longitude 09°30'96.9'' E. Its' altitudes is 1656 m.a.s.l.

2.2. Treatments and Experimental Design

The experiment was consisting of two factors. Seven levels of spacing were 50cm*10cm (194,444 plants ha^{-1}), 50cm*15cm (126,388 plants ha^{-1}), 50cm*20cm (97,222 plants ha^{-1}), 50cm*25cm (77,777 plants ha^{-1}), 60cm*10cm (166,666 plants ha^{-1}), 60cm*15cm (108,333 plants ha^{-1}), 60cm*20cm (83333 plants ha^{-1}), 60cm*25cm (133,333 plants ha^{-1}), 70cm*10cm (138,888 plants ha^{-1}), 70cm*15cm (90277 plant ha^{-1}), 70cm*20cm (69444 plant ha^{-1}), 70cm*25cm (55,555 plant ha^{-1}) and Werer-962 variety were used. The experiment was laid out in Randomized complete Block design with three replications in factorial arrangement. The gross plot area was 12.5m x 29.5m (368.75m^2) and five, six and seven rows were planted depending on the row spacing in each plot. Net Plot size was used 3.5m x 2m (7m^2). The distance between each blocks and plot will be 1m and 0.5m respectively.

Table 1. *Treatments arranged.*

S.N	Treatments	S.N	Treatments
1	50cm*10cm	7	60cm*20cm
2	50cm*15cm	8	60cm*25cm
3	50cm*20cm	9	70cm*10cm
4	50cm*25cm	10	70cm*15cm
5	60cm*10cm (control)	11	70cm*20cm
6	60cm*15cm	12	70cm*25cm

2.3. Experimental Procedures

The experimental field was ploughed and harrowed by a tractor to get a fine seedbed and leveled manually before the field layout was made. Two seeds per hill were planted and thinned to one plant per hill two week after emergence. At planting full dose of NPS fertilizer at the rate of 100 kg ha^{-1} was applied uniformly into all plots. It was harvested from the net plot after they attained their normal physiological maturity.

2.4. Data Collected

Day to flowering was recorded number of days from planting to the time when 50% of the plants produced at least one flower. Days to physiological maturity were recorded number of days from planting to the time when 95% of pods reached maturity. Plant height was measured from the base of plant to the tip of the main stem at the stage of physiological maturity. Number of pods per plant was determined by counting total number of pods from five randomly selected plants from each net plot at the time of harvesting. Number of seeds per pod was counted from 10 pods from net plot at harvested from each net plot. Grain yield was recorded by weighted of harvested grain yield from each net plot.

2.5. Data Analysis

Data analysis of variance was carried using General Linear Model of ANOVA using SAS version 9.1 software (SAS, 2002). Mean separation was carried out using Least Significance Difference (LSD) test at 5% probability level.

3. Results and Discussion

3.1. Seed Yield

The combined analysis showed that main effect and their interaction effect of inter- and intra-row spacing which was highly significantly ($P < 0.01$) affected on pod yield of groundnut (Table 2). The combined mean seed yield range from 1542kg ha^{-1} to 7222kg ha^{-1} at inter- and intra-row spacing 60cm * 20cm and 70cm * 25cm, respectively. The highest adjusted grain yield 2722kg ha^{-1} was obtained at 60cm*20cm inter- and intra-row spacing followed by 2622kg ha^{-1} at (60cm*25cm). While the lowest adjusted grain yields of 1542kg ha^{-1} and 1592kg ha^{-1} were obtained at interaction of and 70cm*25cm and 70cm*20cm inter and intra-row spacing, respectively (Table 3). Inter- and intra-row spacing (60cm * 20cm) was given yield advantage (37.31%) over control inter and intra-row spacing (60cm*10cm). This indicated that the grain yield at the optimum plant densities might be due to efficient utilization of growth resources. Whereas, the lowest grain yield at the largest inter row spacing might be attributed to the more comfortable growth because of the more resources at the lower plant density initiated more pod thickness than the grain yield. This result is in line with [6, 2].

3.2. Days to Flowering

The combined main effect of inter- and intra-row and their interaction had spacing was highly significant ($P < 0.01$), effect on days to 50% flowering (Table 3. The longest days to 50% flowering (38.16 cm) were recorded at inter-row spacing and intra-row spacing of 60cm*25cm and 50cm*15cm, respectively. While the shortest days to 50% flowering (35.33) were recorded at inter-row spacing and intra-row spacing 50cm*10cm (Table 3).

The longest days to flowering with a wider inter- and intra-row spacing might be due to the fact that more nutritional area available in the wider row spacing might have caused the crop to flower later than the narrower spacing. Furthermore, this result might be because wider spacing had a better light interception as compared to the narrow row spacing, resulting in more number of days to flowering of mung bean. This result is in line with [12, 4] who reported that when beans are planted at the lower planting densities, the plants required more number of days for flowering.

3.3. Days to 90% Maturity

The combined main effect of inter- and intra-row spacing and their interaction was highly significant ($P < 0.05$) on days to 90% maturity (Table 1). The longest days to 90% maturity (156.08 days) were recorded at interaction of 60 cm inter- and 10 cm intra-row spacing, while the shortest days to 90% maturity (151.91 cm) was recorded at 70 cm inter- and 10 cm intra-row spacing (Table 3).

3.4. Plant Height (cm)

The combined main effect of inter-spacing was highly significant ($P < 0.01$), while intra spacing and their interaction had no significant effect on plant height (Table 2). The maximum plant height (38.45cm and 38.58cm) were recorded at inter and intra row spacing of 60cm*10cm and 70cm*10cm, respectively (Table 3). While the shortest plant height was measured (33.41cm) from inter and intra row spacing of 50cm*25cm.

3.5. Number of Pod Per Plant

Results from the analysis of variance indicated that intra row space was high significant ($P < 0.01$) but both inter row space and their interaction effect non-significant on the number of pods per plant (Table 2). Pod number per plant was ranged between 28.45 to 40.86 values from combined mean result. As increasing intra and inter row spacing number of pod per plant increased. The highest number of pods per plant (40.86 and 40.18) was obtained from 60cm*25cm and 60cm*20cm inter- and intra-row spacing, respectively. This indicated that due to less competition among the plants to get enough space for their growth and development. These results are agreement with the findings of [6, 11, 5]. While the lowest number of pods per plant (28.45) was found at 50cm*10cm spacing (Table 2).

3.6. Number of Seed Per Pod

The combined analysis showed that both main effect and their interactions effect of inter and Intra-row spacing was not significant on number of seeds per pod (Table 1). This result was in line with the finding of [9] who reported no significant effect of row spacing on number of seeds per pod of mung bean. The present result was in line with [10] who obtained no significant effect of plant density on number of Seed per Pod of soya bean.

Table 2. *The combined mean square values of ANOVA for phenology, growth and yield components of groundnut inter and intra-rows spacing at density at both location in 2019 and 20 cropping season.*

Source Variation	DF	DF	DM	PH	NPPP	NSPP	YLD (kg ha^{-1})
Rep	2	0.35ns	10.58ns	4.45ns	426.17ns	0.02ns	324596.89ns
Intra row	3	6.37**	20.65*	84.55**	684.11**	0.01ns	433137.24ns
Inter row	2	1.66**	31.23*	13.3ns	64.43ns	0.11ns	3346985.51**
Location	1	24.63**	9648.61**	49.47**	891.03**	0.73**	4687607.93**
Inter row * Intra row	6	11.22**	20.12*	5.86ns	47.38ns	0.03ns	954125.64**
Mean		36.85	153.16	35.94	36.29	1.67	2039.851
CV%		2.19	3.94	12.06	29.51	10.61	41.79

Means in the same column and the same letters are not significantly different at 5% level of probability, ns= nonsignificant, CV= coefficient of variation in percent, DF=Days to Flowering, DM=Days to maturity, PH= plant height (cm), NPPP=Number of pod Per plant, NSPP=Number of seed per pod, and YLD= Grain Yield (kg/ha^{-1}).

Table 3. *Combined Mean phenology, growth and yield components of Ground nut inter and intra-rows spacing at density at both location in 2019 and 2020 cropping season.*

Spacing	Plant Density	DF	DM	PH	NPPP	NSPP	YLD (kg ha^{-1})	YLD AD%
50cm*10cm	194,444	35.33e	154.33a-c	36.61bc	28.45c	1.7	1945.83cd	
50cm*15cm	126,388	36.08a	155.08ab	36.00b-d	35.18a-c	1.71	2020.83c	1.92
50cm*20cm	97,222	36.50dc	153.58a-c	35.73c-e	36.82ab	1.75	2239.28bc	12.93
50cm*25cm	77,777	36.41dc	152.66bc	33.41f	36.35ab	1.68	1891.66cde	
60cm*10cm (control)	166,666	37.75a	156.08a	38.45a	32.18bc	1.76	1982.73cd	
60cm*15cm	108,333	36.00d	152.91a-c	35.60c-e	36.63ab	1.75	2140.47c	7.95
60cm*20cm	83,3333	37.08b	155.41c	34.91c-f	40.18a	1.78	2722.61a	37.31
60cm*25cm	66,666	36.75bc	153.66a-c	34.25ef	40.86a	1.71	2622.02ab	32.24
70cm*10cm	138,88	36.58bc	151.91bc	38.58a	29.00c	1.7	1842.85cde	
70cm*15cm	90,277	36.66bc	152.16bc	37.48ab	35.15a-c	1.76	1934.76cde	
70cm*20cm	69,444	36.91bc	152.33bc	35.43c-e	37.46ab	1.76	1592.85de	
70cm*25cm	55,555	38.16a	154.83bc	34.88d-f	36.24ab	1.76	1542.26e	
Mean		36.854	153.16	35.94	35.33	1.73	2039.85	
CV%		1.67	1.87	4.14	17.21	6.54	16.87	
LSD 0.05		0.87**	3.31*	1.72*	7.03*	NS	397.7**	

Means in the same column and the same letters are not significantly different at 5% level of probability, ns= nonsignificant, LSD= least significant difference at 5% level of significant, CV= coefficient of variation in percent, DF=Days to Flowering, DM=Days to maturity, PH= plant height (cm), NPPP=Number of pod Per plant, NSPP=Number of seed per pod, and YLD= Grain Yield (kg ha^{-1}), YLD AD%=Yield advantage in percentage.

Table 4. *Combined Mean grain yield and agronomic traits of groundnut plant density at Mechara on station in 2019 and 2020 cropping season.*

TRT	DM	PH	NPPP	NSPP	YLD (Kg/ha)	YLD AD%
50cm*10cm	163.33ab	37.06ab	27.26d	1.50b	1969.04bd	
50cm*15cm	163.33ab	34.66de	31.80b-d	1.56ab	1654.76cd	
50cm*20cm	162.33a-c	34.36de	31.65b-d	1.60ab	1855.95cd	
50cm*25cm	160.50bc	33.13e	36.56a-c	1.50b	1666.66cd	
60cm*10cm (control)	166.00a	37.43a	2963cd	1.66ab	2042.85a-c	
60cm*15cm	161.83a-c	35.46b-d	32.63b-d	1.56ab	2042.85a-c	
60cm*20cm	158.33c	35.10cd	41.56a	1.66ab	2600.76a	27.31
60cm*25cm	162.00a-c	34.20de	39.76ab	1.66ab	2495.23ab	22.24
0cm*10cm	159.16bc	37.23a	26.80d	1.56ab	1425d	
70cm*15cm	161.16a-c	3653a-c	33.80a-d	1.70a	1573.81cd	
70cm*20cm	159.50bc	34.40de	37.56a-c	1.70a	1594.04cd	
70cm*25cm	159.16bc	34.50de	37.10a-c	1.60ab	1438.09d	
Mean	161.4	35.34	33.84	1.6	1863.59	
CV	1.81	2.83	15.38	6.57	18.31	
LSD 0.05	4.96*	1.69*	8.79*	0.17*	576.43**	

Means in the same column and the same letters are not significantly different at 5% level of probability, ns= nonsignificant, LSD= least significant difference at 5% level of significant, CV= coefficient of variation in percent, DF=Days to Flowering, DM=Days to maturity, PH= plant height (cm), NPPP=Number of pod Per plant, NSPP=Number of seed per pod, and YLD= Grain Yield (kg ha^{-1}), YLD AD%=Yield advantage in percentage.

Table 5. *Combined Mean grain yield and agronomic traits of groundnut plant density at Milkaye FTC in 2019 and 2020 cropping season.*

TRT	DM	PH	NPPP	NSPP	YLD (Kg ha^{-1})	YLD AD.%
50cm*10cm	145.33	36.16b-e	29.63b	1.9	1922.61def	
50cm*15cm	146.83	37.33a-c	38.56ab	1.86	2386.905a-d	
50cm*20cm	144.83	37.10a-d	42.00a	1.9	2622.61a-c	
50cm*25cm	144.83	33.70e	36.13ab	1.86	2116.66c-e	
60cm*10cm (control)	146.16	39.46a	34.73ab	1.86	1922.61def	
60cm*15cm	144	35.73b-e	40.63ab	1.93	2238.09b-d	
60cm*20cm	144.5	34.73c-d	42.80a	1.9	2840.47a	47.74
60cm*25cm	145.33	34.30de	41.96a	1.8	2748.81ab	42.97
70cm*10cm	144.5	39.93a	30.23b	1.83	2260.71b-d	
70cm*15cm	143.16	38.93ab	36.50ab	1.83	22295.71b-d	
70cm*20cm	145.16	36.46b-e	33.36b	1.83	1591.66f	
70cm*25cm	144.5	35.26c-e	35.38ab	1.93	1646.42ef	
Mean	144.93	36.55	36.82	1.87	2216.1	
CV	2.11	4.79	18.22	6.36	13.65	
LSD 0.05	NS	2.96*	11.33*	NS	511.19***	

Means in the same column and the same letters are not significantly different at 5% level of probability, ns= nonsignificant, LSD= least significant difference at 5% level of significant, CV= coefficient of variation in percent, DF=Days to Flowering, DM=Days to maturity, PH= plant height (cm), NPPP=Number of pod Per plant, NSPP=Number of seed per pod, and YLD= Grain Yield (kg ha^{-1}), YLD AD%=Yield advantage in percentage.

4. Conclusion and Recommendation

Generating reliable information on agronomic management practices such as appropriate row and plant spacing is quite important to come up with profitable and sustainable ground nut production and productivity. In view of this, an experiment was conducted to determine the effect of intra- and inter-row spacing on the yield and yield components of groundnut variety. This study provides evidence that inter- and intra-row spacing has influence on the phenology, growth, yield and yield components of groundnut. The combined mean was observed inter- and intra-row spacing significant different for days to flowering, days to maturity, plant height, number of pods per plant, grain yield. While, non-significant different showed for number of seed per pod. The highest grain yield (2722kg ha^{-1}) was obtained at interaction of 60cm * 20cm spacing. While the lowest (1542 ha^{-1} and 1592 ha^{-1}) were obtained at 70cm*25cm and 70cm*20cm inter- and intra-row spacing, respectively. 60cm*20cm spacing was given 37.31% yield advantage over control 60cm*10cm spacing Therefore, 60cm*20cm is recommend as the optimum spacing for the high yield production of ground nut in west Hararghe zone and similar agro ecologies.

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