

Evaluation of the Effects of Intra and Inter Row Spacing on the Growth and Yield of Ground Nut (*Arachis Hypogaea* L.) at Haro Sabu, Western Ethiopia

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Abstract

Ground nut (*hypogaea* L.) is one of most important food crop grown in Oromia Regional State, Ethiopia. However, its productivity is very low due to inappropriate intra and inter spacing practice. Thus, the study was conducted in 2016 and 2017 during the main cropping season at Haro Sabu Agricultural Research Center and Kombo subsite of Kelem Wollega zone of Western Ethiopia to identify the effects of different spacing on growth parameters, yield and yield components of ground nut varieties. The experiment was laid out in Randomized complete Block design with three replications in factorial arrangement. The experiments consist of two factors. Nine levels of spacing were 50cmx5cm, 50cmx10cm, 50cmx15cm, 60cmx5cm, 60cmx10cm, 60cmx15cm, 75cmx5cm, 75cm x10cm, 75cm x15cm and two varieties (Manipinter and Sartu). The highest total number of pods per plant (21.36) was obtained from variety manipinter. Regarding to spacing, the highest number of pods per plant (25.00) was obtained from 75cmx10cm and followed by 75cmx15cm (22.45). The highest hundred seed (66.85g) weight and grain yield (2105 kg ha⁻¹) was recorded from manipinter variety. Regarding to spacing, the highest grain yield (2474 and 2433 kg ha⁻¹) was obtained from 50cmx5cm and 60cm x5cm respectively. The highest net benefit (50269.00 and 50245.00 ETB ha⁻¹) was recorded from 50cmx5cm and 60cmx5cm spacing respectively. However the highest marginal rate return (288.46%) was recorded from spacing 60cm x 5cm followed by 50cm x 5cm (2.66%). Therefore spacing of 50cmx5cm and 60cmx5cm was optimum plant population density for production of ground nut in Kelem Wollega zone of western Ethiopia.

Keywords: *Arachis hypogaea* L., grain yield, interaction effect, spacing

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INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important monoecious annual legume used for oilseed, food and animal feed (Pande *et al.*, 2003; Upadhyaya *et al.*, 2006). It is the main source of food in various forms and used as a component of crop rotation in many countries (Gbèhounou and Adengo, 2003). Groundnut is grown on 26.4 million ha worldwide with a total production of 38.2 million metric tons (FAOSTAT, 2010). Developing countries account for 97% of the world's groundnut area and 94% of the total production.

The lowland areas of Ethiopia have considerable potential for increased oil crop production including groundnut. The estimated production area and yield of groundnut in Ethiopia in 2016/2017 cropping season were 74861.37 hectares and 1296364.18 quintals, respectively (CSA, 2017). The seed yield is a function of interaction between genetic and environmental factors including soil type, sowing time and method, seed rate, fertilizers and time of irrigation among which, row spacing plays a vital role in getting higher yield (Hussain *et al.*, 2003). Proper spacing ensures adequate ventilation, reduces competition among plants for space and nutrients, and reduces transmission of diseases, facilitates weeding and movement in the farm and also reduces overcrowding and, therefore; allows interception of radiation by plant canopies.

The response of ground nut to plant density has been investigated in many areas of the world. Investigation of growth and yield performance of ground nut with special reference to arrangement has been conducted and the result showed that leaf area index, crop growth rate, pod growth rate, pod and kernel yield have increased by increasing plant density (Kiniry *et al.*, 2005). Cultivation of groundnut in narrow rows can lead to maintenance of a complete crop cover over the soil which inhibits weed seed germination and reduces the need to carry out weeding (Lee *et al.*, 1994). Early canopy closure by closely spaced groundnut crop has been shown to smother weeds hence reducing weed/crop competition, especially for soil nutrients and water. Such benefits are more evident under low input conditions as seen on most smallholder farms.

Some investigators concluded that narrow row spacing was superior in yield and more economical than broader rows (Pereira *et al.*, 1988). Plants growing in too wide rows may not efficiently utilize the natural resources such as water and nutrients, whereas growing in too narrow rows may result in severe inter and intra-row spacing competition (Ali *et al.*, 1999). Therefore, it is of crucially important to manipulate the row spacing in order to increase plant productivity. Production of groundnut is under progress since recently in west and Kellem Wollega zones. The information of agronomic practices such as row and planting spacing is limited because it is produced at subsistence level by rural farmers and the farmer cultivate ground nut without consideration of the appropriate row and plant spacing. Research on manipulating plant density and their effects on growth and yield

are crucial so as to generate enough information and data base for use by emerging farmers that would be interested in commercial production of this crop. Thus, the present investigation was aimed to determine the effects of row and plant spacing on growth parameters, yield and yield component of ground nut varieties.

MATERIALS AND METHODS

Description of the Study Area

The experiment was conducted at Haro Sabu Agricultural Research Center (HARC) and Kombo subsite during 2016 and 2017 the main cropping season. HARC and kombo were located in kellem wollega zone, western Ethiopia at 550 and 580 km away from Addis Ababa and 1530m above sea level. The area receives average annual rain fall of 1000 mm and its distribution pattern is uni-modal. The rain periods covers from April to October at both site. The soil type of the experimental site was reddish brown and its pH is 5.82. The area is characterized by crop livestock mixed farming system in which cultivation of maize, sorghum, finger millet, haricot bean, soybean, sesame, ground nut, coffee, banana, mango, sweet potato and coffee are the major crops grown in the area.

Treatments and Experimental Design

The experiment was consist of two factors. Nine levels of spacing were 50cmx5cm (400,000plants ha⁻¹), 50cmx10cm (200,000plants ha⁻¹), 50cmx15cm (133,333plants ha⁻¹), 60cmx5cm (333,333plants ha⁻¹), 60cmx10cm (166,670plants ha⁻¹), 60cmx15cm (111,113plants ha⁻¹), 75cmx5cm (266,666plants ha⁻¹), 75cmx10cm (133,330plants ha⁻¹), 75cmx15cm (88,887plant ha⁻¹) and two varieties (Manipinter and Sartu). The experiment was laid out in Randomized complete Block design with three replications in factorial arrangement. The gross plot area was 3mx3.9m =11.7m² and Four, five and six rows were planted depending on the row spacing in each plot

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 one week after emergence. At planting full dose of DAP (18% N, 46% P₂O₅) 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.

Data Collection

Data were collected on: Days to flower initiation, Days to physiological maturity, Number of primary branches, Plant height (cm), Number of pods plant⁻¹, Number of seeds pod⁻¹, Hundred grain weight (g) and Grain yield (kg ha⁻¹) were recorded. Days to flower initiation was recorded as the number of days from planting to the time when 50% of the plants produced at least one flower. Days to physiological maturity was recorded as the number of days from planting to the time when 95% of pods reached maturity. Number of primary branches was determined by taking five randomly selected plants per plot at harvesting time. 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 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 determined by counting total seeds of counted pods from five randomly selected plants and divided by the total number of pods. Hundred grain whight was recorded by weighted hunderde seed. Grain yield was recorded by weighted of harvested grain yield from each net plot

Data Analysis

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.

Economic analysis

The partial budget analysis as described by CIMMYT (1988) was done to determine the economic feasibility of row and plant spacing practices. Economic analysis was done using the prevailing market prices for inputs at planting and for output at the time of crop harvest. It was calculated by taking into account the additional input and labour cost involved and the gross benefits obtained from row and plant spacing practices. The field price of 1 kg of groundnut that farmers receive from sale for the crop was taken as 25 Birr based on the market price of groundnut at Harosebu near the experimental site. The average yield was adjusted downward by 10% to reflect the difference between the experimental yield and the yield farmers could expect from the same weed management practices as described by CIMMYT (1988). The field price of groundnut was calculated as sale price minus the costs of harvesting, threshing, winnowing, bagging and transportation. The total cost that varied included the sum of cost of seed and labour cost management practice is required. The net benefit was calculated as the difference between the gross field benefit (Ethiopian birr ha⁻¹) and the total costs (Ethiopian birr ha⁻¹) that varied.

RESULTS AND DISCUSSION

The analysis of variance revealed that days to 50% flower initiation and days to physiological maturity were highly significantly ($P \leq 0.01$) affected by varieties. Varieties 'Manipinter' reached to 50% flower initiation on

average 50.48 days while variety Sartu took on the average 42.55 days. Similarly, the respective days to reach to 95% physiological maturity for variety Manipinter and Sartu were 173.76 and 164.28 days, respectively (Table 1). From this result, it is clear that variety ‘Sartu’ flowered and matured earlier than the Manipinter variety. This difference observed in phenological parameters could be due to the inherent characteristics or genetic makeup of the varieties. In agreement with this result with Kamara *et al.* (2011) reported that there were significant differences among varieties for days to flowering and maturity. Similarly, crop phenological development (emergence and flowering) significantly differed among the groundnut varieties were reported by Arrison *et al.* (2014).

The effect of spacing and interaction of varieties and spacing showed statically no significant effect on days to flowering and days to physiological maturity. This result was in agreement with Arrison *et al.* (2014), reported that spacing and the interaction effect of ground nut varieties and spacing had no significant effect on days to flowering and physiological maturity.

here were significant differences among varieties for days to flowering, maturity, number of pods per plant, pod, and fodder yield in both locations.

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Table 1: Main effects of varieties and spacing on Phenological and Growth parameters during 2016 and 2017 growing season of both location

Treatments	DF	DPM	PH	PBPP
Variety				
Sartu	42.55 ^b	164.28 ^b	44	6.59
Manipinter	50.48 ^a	173.76 ^a	42	6.96
LSD_(0.05)	0.17	0.25	NS	NS
Spacing				
50cmx5cm (400,000pl/ha)	46.75	169.25	43.75	6.65
50cmx10cm (200,000pl/ha)	46.67	169.08	44.83	6.30
50cmx15cm (133,333pl/ha)	46.58	168.75	40.77	7.13
60cmx5cm (333,333pl/ha)	46.41	168.92	45.37	6.11
60cmx10cm (166,670pl/ha)	46.58	169.17	44.82	7.22
60x15cm (111,113pl/ha)	46.33	169.00	43.19	6.91
75cmx5cm (266,666pl/ha)	46.33	169.33	43.80	6.93
75cmx10cm (133,330pl/ha)	46.41	169.00	43.22	6.61
75cmx15cm (88,887pl/ha)	46.58	168.67	43.13	7.09
LSD_(0.05)	NS	NS	NS	NS
CV(%)	1.39	0.55	15.51	24.44

DF=Days to flowering; DPM=Days to physiological maturity; PH=plant height; PBPP=Primary branch per plant, LSD=Least Significant Difference ($P \leq 0.05$); CV=Coefficient of Variation; NS=Non Significant

The effect of variety and spacing was highly significant ($P \leq 0.01$) effect on total number of pods per plant. But the interaction effect of variety and spacing was non-significant. The highest total number of pods per plant (21.36) was obtained from variety manipinter (Table 2). The variations in the number of pods observed were probably largely attributable to the genotypes of the ground nut variety (Virk *et al.*, 2005). This finding in agreement with Konlan *et al.* (2013) reported that number of pods per plant were significantly differed between varieties. With regards to spacing, the highest number of pods per plant (25.00 and 22.45) were obtained from 75cmx10cm and 75cmx15cm, respectively. The higher number of pods per plant recorded by wide spacing arrangements may be due to lesser intra-specific competition for growth resources among the wide spacing compared to close spacing crop lower plant density and more available growth resource. Virk *et al.* (2005) and Abdullah *et al.* (2007) reported that increased plant density decreased number of pods per plant and as plant density decreased number of pods per plant increased. In general, total number of pods per plant was low in plots with the highest plant densities and high in plots containing lowest plant densities.

The main effect of variety was significantly ($P \leq 0.01$) affect number of seeds per pod. while the main effect of spacing and interaction effect of variety and spacing was non- significant on number of seeds per pod. Among the varieties, the highest number of seeds per pod (1.70) was obtained for the variety sartu (Table 2). Number of seeds per pod may be a varietal difference; which is largely controlled by plant genetic factors than agronomic practices.

Hundred seed weight was significantly affected ($P \leq 0.01$) by varieties but not by spacing and interaction effect. The highest hundred seed (66.85g) weight was recorded from manipinter variety. The varietal differences in hundred seed weight were mainly genotypic manifestation, since the seeds of manipinter were generally larger and bigger (Table 2)

Grain yield was highly significantly ($P \leq 0.01$) affected by main effect of variety and spacing. Whereas, the interaction effect of variety and spacing was non-significant effect on grain yield. The highest grain yield (2105 kg ha^{-1}) was obtained from variety mainipinter while the lowest grain yield (1373 kg ha^{-1}) was obtained from variety 'sartu' (Table 2). The highest grain yield produced by variety 'mainipinter' could be attributed to its more hundred seed weight. The variations in grain yield of varieties was probably attributable to genetic differences between varieties. Similar findings have been reported by earlier studies (Abdullah et al., 2007; Virender and Kandhola, 2007). Regarding to spacing, the highest grain yield (2474 and 2433 kg ha^{-1}) was obtained from $50\text{cm} \times 5\text{cm}$ and $60\text{cm} \times 5\text{cm}$, respectively (Table 2). The grain yield at the higher plant densities might be due to efficient utilization of growth resources and the lowest grain yield at the lowest plant density might be attributed to the more luxurious growth because of the more resources at the lower plant density initiated more pod thickness than the grain yield. In line with this result, Bihter O. *et al.* (2017) found that Pod yield per hectare was increased when the plant density was increased; the highest pod yield ($7511.9 \text{ kg ha}^{-1}$) was obtained from $75\text{cm} \times 10\text{cm}$ and the lowest (5171 kg ha^{-1}) was from $75\text{cm} \times 25\text{cm}$ planting density. Also Naeem *et.al.* (2007) reported that significant variation was observed on pod yield due to row spacing; the highest (3739 kg ha^{-1}) and the lowest (1903 kg ha^{-1}) pod yield was recorded from 30cm and 60cm row spacing respectively. Generally, decrease in spacing reduced the number of pods per plant but the additional plants m^{-2} more than compensated for the reduction, resulting in higher pod yield. Such compensation effects have been reported by Ahmad *et al.* (2007), Norden and Lipscomb (1974). Thus spacing arrangement that resulted in high plant population density was more efficient in the use of solar energy and other resources for pod production (Virk *et al.*, 2005).

Table 2: Main effects of varieties and spacing on yield and yield component during 2016 and 2017 growing season of both location

Treatment	NPPP	NSPP	HGW	GY(kg ha^{-1})
Variety				
Sartu	19.33 ^b	1.70 ^a	41.27 ^b	1373 ^b
Manipinter	21.96 ^a	1.51 ^b	66.85 ^a	2105 ^a
LSD _(0.05)	1.32	0.07	2.37	116
Spacing				
50cmx5cm (400,000pl/ha)	18.25 ^c	1.52	55.34	2474 ^a
50cmx10cm (200,000pl/ha)	20.03 ^{bc}	1.59	55.46	2140 ^b
50cmx15cm (133,333pl/ha)	19.60 ^c	1.63	53.79	1323 ^c
60cmx5cm (333,333pl/ha)	18.73 ^c	1.7	53.02	2433 ^a
60cmx10cm (166,670pl/ha)	20.88 ^{bc}	1.61	55.28	1918 ^b
60x15cm (111,113pl/ha)	20.81 ^{bc}	1.72	53.53	1260 ^c
75cmx5cm (266,666pl/ha)	20.07 ^{bc}	1.51	55.37	1895 ^b
75cmx10cm (133,330pl/ha)	25.00 ^a	1.59	52.98	1258 ^c
75cmx15cm (88,887pl/ha)	22.45 ^{ab}	1.61	51.78	951 ^d
LSD _(0.05)	2.81	NS	NS	245.65
CV(%)	23.90	17.05	16.37	24.80

Means within the same column followed by the same letter or by no letters of each factor do not differ significantly at 5% probability level; LSD=Least Significant Difference ($P < 0.05$); CV=Coefficient of Variation; NS=Non Significant; NPPP=Number of pod per plant; NSPP=Number of seed per pod; HGW=Hundred grain weight; GY=Grain yield

The economic analysis results for intra and inter row spacing are indicated in Tables 3. The highest net benefit of $\text{ETB } 50269 \text{ ha}^{-1}$ and marginal rate return of 2.6 % was obtained from $50\text{cm} \times 5\text{cm}$ spacing for groundnut production followed by net benefit of $\text{ETB } 50245 \text{ ha}^{-1}$ and marginal rate return of 288.46 % from $60\text{cm} \times 5\text{cm}$ spacing (Table 3). However; the highest marginal rate return (2874.14%) was recorded from spacing $60\text{cm} \times 10\text{cm}$ followed by $60\text{cm} \times 15\text{cm}$ (2213.7%). Thus, practicing of $50\text{cm} \times 5\text{cm}$ and $60\text{cm} \times 5\text{cm}$ spacing resulted in 18.6 % increment to the groundnut income from that of $60\text{cm} \times 10\text{cm}$ spacing practice. Thus, $50\text{cm} \times 5\text{cm}$ and $60\text{cm} \times 5\text{cm}$ is economically feasible for groundnut production in study area.

Table 3. Effects of intra and inter row spacing on economic feasibility of groundnut production

Treatment	Yield (kg ha ⁻¹)	Adj yield (kg ha ⁻¹)	Price ETB kg ⁻¹	Revenue (ETB ha ⁻¹)	Marginal cost (ETB ha ⁻¹)	Net profit (ETB)	MRR(%)
75cmx15cm	951	856	25	21400	1201.31	20198.69	0
60cmx15cm	1260	1134	25	28350	1501.69	26848.31	2213.7
75cmx10cm	1258	1132	25	28300	1801.95	26498.05	D
50cmx15cm	1323	1190	25	29750	1802.00	27948.00	366.18
60cmx10cm	1918	1726	25	43150	2252.55	40897.45	2874.14
50cmx10cm	2140	1910	25	47750	2703.00	45047.00	921.20
75cmX5cm	1895	1705	25	42625	3603.99	39021.01	D
60cmx5cm	2433	2190	25	54750	4505.00	50245.00	288.46
50cmx5cm	2474	2227	25	55675	5406.00	50269.00	2.66

Adj. yield= adjusted yield, ETB =Ethiopian birr , ETB kg⁻¹= Ethiopian birr per kilogram, MRR= Marginal Rate Return

Conclusion and recommendations

Planting density is one of the main factors that have an important role on growth, yield and quality of ground nut. It is important to accommodate the most appropriate number of plants per unit area of land to obtain better yield.

The highest total number of pods per plant (21.36) was obtained from variety manipinter. With regards to spacing, the highest number of pods per plant (25.00 and 22.45) was obtained from 75cmx10cm followed by 75cmx15cm respectively. The highest grain yield (2105 kg ha⁻¹) was obtained for variety mainipinter while the lowest grain yield (1373 kg ha⁻¹) was obtained for variety 'sartu'. Regarding to spacing, the highest grain yield (2474 and 2433 kg ha⁻¹) was obtained from 50cmx5cm and 60cmx5cm, respectively. Generally, decrease in spacing reduced the number of pods plant⁻¹ of ground nut, but the additional plants m⁻² more than compensated for the reduction, resulting in higher grain yield. Economic analysis of different spacing revealed that gave different economic return as compared to control (60cmx10cm). The highest net benefit (50269.00ETB ha⁻¹) was recorded from 50cmx5cm spacing followed by 60cmx5cm spacing (50245.00ETB ha⁻¹). Therefore spacing of 50cmx5cm and 60cmx5cm was optimum plant population density for production of ground nut in Kelem Wollega zone of western Ethiopia.

REFERENCES

- A.Y. Kamara, F. Ekeleme, J.D. Kwari, L.O. Omoigui and D. Chikoye, 2011 Phosphorus effects on growth and yield of groundnut varieties in the tropical savannas of northeast Nigeria. *Journal of Tropical Agriculture* 49 (1-2): 25-30
- Abdullah, T., Rahmianna, A.A., Hardaningsih, S. and Rozi, F. 2007. Increasing groundnut yield on dry land Alfisols in Indonesia. *Journal of Semi-Arid Tropics Agricultural Research*, 5(1): 84 - 96.
- Ahmad N, Mohammad R, Ulas K . 2007. Evaluation of different varieties, seed rates and row spacing of groundnut, planted under agro-ecological conditions of Malakand Division. *Journal of Inter academia* 9(4):178-183.
- Ali Y., Ahsanul Hag M., Tahir G.R., Ahmad N.,1999. Effect of Inter and Intra Row Spacing on the Yield and Yield Components of Chickpea. *Pak. Journal of Biological Science*, 2 (2): 305-307
- Arrison Kwame Dapaah, Ibrahim Mohammed and Richard Tuyee Awuah,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.
- Bihter Onat, Halil Bakal , Leyla Gulluoglu , Halis Arioglu 2017. The effects of row spacing and plant density on yield and yield components of peanut grown as a double crop in mediterranean environment in turkey. *Turk journal of field crops* 22(1), 71-80
- CIMMYT (International Maize and wheat improvement center) 1198.From agronomic data to farmer recommendations. Economics training manual completely revised edition, MECECO.
- CSA (Central Statistical Agency), 2017. The federal democratic republic of Ethiopia central statistical agency, Agricultural sample survey. Volume I, Report on area and production of major crops (private peasant holdings, meher season), Addis Ababa, Ethiopia.
- FAOSTAT. 2010. Groundnut world production. <http://www.faostat.fao.org>.
- Gbèhounou, G. and Adengo, E., 2003. From a crop rotation experiment at Akron. Effect of citric acid on aflatoxin degradation and on functional and textural. *Food Research International*, Volume 42, Issue 8
- Hussain I., Ayyaz Khan M., Ahmad K., 2003. Effect of row spacing on grain yield and the yield components of wheat (*Triticum aestivum* L.). *Pak. Journal of Agronomy* 2 (3): 153-159.

- Kiniry, J.R., Simpson, C.E., Schubert, A.M. and Reed, J.D. 2005. Peanut leaf area index, light interception, radiation use efficiency, and harvest index at three sites in Texas. *Field Crop Research* 91:297-306
- Konlan, S., SARKODIE-ADDO, J., Asare, E. and Kombiok M. J. 2013. Groundnut (*Arachis hypogaea* L.) varietal response to spacing in the Guinea savanna agro-ecological zone of Ghana: Growth and yield *African Journal of Agricultural Research* 8(22), 2769-2777
- Lee HC, Berry MP, De Toledo VC, Deffune G, Haymes R, Lopez RJ, Morrish CJ, Rodrigues R, Scofield AM, Watt TA, Wu BZ (1994). Nonchemical weed management in major UK arable crops. In: Arable farming under CAP reform. Clarke J, Lane A, Mitchel A, Ryans P (Eds), Aspects of applied Biology. 40:317-324.
- Naeem Ahmad, Mohammad Rahim and Ulas Khan, 2007. Evaluation of different varieties, Seed Rates and Row Spacing of groundnut, planted under Agro-ecological Conditions of Malakand Division. *Journal of Agronomy*, 6: 385-387
- Norden AJ, Lispcomb RW (1974). Influence of plant growth habit on peanut production in narrow rows. *Crop Science*. 14:454-457.
- Pande, N., Saxena, J. and Pandey, H. 2003. Natural occurrence of mycotoxins in some cereals. *Mycoses*, 33:126-128
- Pereira L.R., Bainer A.C., Vellase J.A.R., 1988. Santos H.P., Row spacing and seed rate in two wheat cultivars. *Pesquisa Agropecuaria Brasileira*, 23: 1143-1149
- Upadhyaya, H.D., Reddy, L.J., Gowda, C.L. and Singh, S. 2006. Identification of diverse groundnut germplasm: Sources of early maturity in a core collection. *Field Crops Research*, 97: 261-271.
- Virender S, Kandhola SS . 2007. Productivity of semi-spreading and bunch type varieties of groundnut as influenced by sowing dates. *J.SAT Agric. Res.* 5(1).
- Virk AS, Kaul JN, Bhangoo BS, Singh A . 2005. Influence of planting techniques and plant population on Biology and pod productivity of summer groundnut varieties. *Research Crops* 6(1):173-174.