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Influence of Intra and Inter Row Spacing on Seed Yield and yield component of Chickpea (*Cicer arietinum*) Varieties in Central Highlands of Ethiopia

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Abstract: **Chick pea is an important source of human food and animal feed. Limited studies were employed on the influence of plant population on seed yield and quality of chick pea in the central highlands of Ethiopia. In view of this, a field experiment was conducted at Debre Zeit Agricultural research center and its sub-site (Akaki) in the 2015 and 2016 main cropping season with the objectives to investigate the effects of row and plant spacing on, seed quality and chickpea seed production and to determine the appropriate intra and inter row spacing for chickpea seed production. The treatments included two chick pea varieties; four level of intra row spacing and three levels of inter row spacing. The experiment was laid out in a randomized complete blocked design with three replications. The highest number of pods plant^{-1} was obtained with the interaction effect of 40 cm inter- and 20 cm intra- row spacing's. The highest above ground dry biomass (4.35 t ha^{-1}) was recorded at (5 cm) intra- spacing and the lowest dry biomass (3.53 t ha^{-1}) was recorded at 20cm intra-spacing. The highest hundred seed weight (30.95g) was observed with 5 cm intra- row spacing which had no significant difference with 10 cm intra-row spacing. The interaction of 30 cm inters- and 5 cm intra- row spacing resulted in the highest grain yield (1.95 t ha^{-1}). The lowest grain yield (1.51 t ha^{-1}) was recorded with the interaction of 30 cm × 20 cm. The highest mean harvest index (45.45%) of chick pea was obtained from interaction of 40 x 15 cm inter and intra row spacing. Therefore, 40 cm inter-row with 15 cm intra-row spacing can be recommended for the production of chickpea in the study area as compared to the current grain production recommendation of 30 x 10 cm.**

Keywords: **Chickpea, Inter- row, Intra- row, Variety, Yield.**

1. INTRODUCTION

Chickpea (Cicer arietinum L.) is an important cool-season annual food and cash crop for many households in Ethiopian highlands. Ethiopia is considered a secondary center of genetic diversity for chickpea (Yadeta and Geletu, 2002; Kanouni *et al*., 2011). Chickpea varieties are the most important crop in terms of local and export market due to their large-seeded type. Seed is a living product that must be grown, harvested and processed correctly to maximize its viability and subsequent crop productivity. According to Govind pal, 2016, the contribution of good quality seed alone can increase to the total production about 15 - 20 percent depending on crops with effective management of other inputs. Moreover, high quality seed enables farmers to attain crops, which have: the most economical planting rate, a higher percentage of seed yield, a minimum of replanting, a vigorous seedling establishment, a more uniform plant stand, faster growth rate, and greater resistance to stress and diseases and uniformity in ripening. Lack of quality seed of improved chickpea varieties are among the major challenges in the central highlands of Ethiopia.

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One of the factors that influence the quality of seeds produced by farmers is improper plant population. Too low and high plant population beyond a certain limit often adversely affects the crop yield. The number of plants per unit area influences plant size, yield components, and ultimately the seed yield (Beech, D. F., and G. L. Leach. 1989). In most parts of the country, the farmers do not use the recommended seed rate by researchers as they usually use higher seed rates. Increasing plant population above the recommended level reduces individual seed size due to the increased competition for the same resource. As a result, the quality of seed produced will be low physically and physiologically

On the other hands, the seed rate recommendation on chickpea so far is for grain production only while the seed multiplication factor is substantially affected by the amount of seed sown. Moreover, plant spacing determines the area available to each plant which in turn determines nutrient and moisture availability to the plant. High quality seed is achieved due to the use of optimum row and plant spacing that determines resource availability and utilization. However, appropriate intra and inter row spacing for quality seed production chickpea growing areas were not well studied and documented.

Therefore, this study was initiated with the objectives

- To investigate the effects on row and plant spacing for seed yield and yield components of chickpea varieties
- To determine the appropriate intra and inter row spacing for chickpea seed production

2. MATERIALS AND METHODS

The field experiment was carried out at Debre Zeit Agricultural research center main station and at Akaki sub-station in the 2015 and 2016 main cropping seasons. Pre-basic seeds of Chickpea varieties produced at Debre Zeit Agricultural research center in 2014 main season were used for the experiment. Factorial combinations of two levels of varieties (Natoli and Habru), four level of intra row spacing (5, 10, 15 and 20cm) and three levels of inter row spacing (20, 30 and 40cm) were arranged in randomized complete block design (RCBD) with three replications. Seed dressing (fungicides) were performed for both varieties to obtain uniform germination. The distance between blocks and plots were 1m and 0.5m, respectively. Total plot area of $7.2m^2$ (2.4m x 3m) were used. The seeding rates for the two varieties in respective row spacing were calculated by using the following formula:-

$$\text{Seeding Rate (kg/ha)} = \frac{\text{100 seed weight (grams)} \times \text{Target plant population (per } m^2) \times 1000}{\text{Germination \%} \times \text{Estimated Establishment \%}}$$

2.1 Data Collected

The routine agronomic data such as days to emergence, days to flowering, days to heading, days to physiological maturity, number of seeds per pod, total above ground biomass, seed yield, harvest index and hundred seed weight were recorded as per prescribed procedures. The data obtained from the field were analyzed using ANOVA appropriate to SAS software (SAS, 2002). Mean comparison was performed using least significant difference (LSD) test at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1 Phenological Parameters

3.1.1 Days to 50% flowering

The main effect of inter-row and intra- spacing's was highly significant ($P<0.01$) (Table 1) While their interaction had no significant effect on days to 50% flowering (Table 3). In agreement with this result, Turk et al. (2003) found that the denser plant population has extended days to flowering in lentils. This might be in contrary to the fact that wider inter - row spacing had a better light interception as compared to the narrower row spacing resulting in less number of days to flower as chickpea needs direct sunlight coverage for their various physiological processes. Therefore, the result suggests that days to flowering vary from crop to crop as well as the prevailing environmental conditions under which the crops are grown.

3.1.2 Days to physiological maturity

Days to physiological maturity were highly significantly (P<0.01) affected by the main effect of inter-row and intra-spacing (Table 3) but, the interaction effect was not significant (P>0.05) for this parameter. Significantly higher days to physiological maturity (114.95) was recorded from inter spacing of 40 cm while, the earlier days to physiological maturity (113.63) was recorded from inter spacing (20cm) (Table 1). The narrowest intra row spacing (5 cm) took (113.15) days to attain physiological maturity which was significantly enhanced by wider spacing's of 10, 15 and 20 cm spacing (Table 1). This may be disagreement with the fact that the prolonged days to maturity in the case of narrower intra row - spacing could be because of high competition for available resources in the soil, poor light interception and air circulation in the canopy as compared to the wider inter- row spacing.

Table 1: Main effects of inter- and intra- row spacing on days to 50% flowering, days to physiological maturity, plant height, plant stand count at emergency ant plant stand count at harvest of chickpea.

Treatments	DF	MD	PH	SCE	SCH
Varieties					
N	55.73[a]	115.56[a]	40.16	139.06[a]	96.95[a]
H	51.62[b]	112.62[b]	40.43	129.48[b]	89.25[b]
LSD (5%)	0.44	0.74	NS	8.51	4.90
Inter-row spacing(cm)					
20	53.13[b]	113.63[b]	40.05	153.34[a]	103.17[a]
30	53.61[b]	113.69[b]	40.29	132.79[b]	96.55[b]
40	54.28[a]	114.95[a]	40.54	116.68[c]	79.59[c]
LSD (5%)	0.59	0.89	NS	10.55	6.19
Intra-row spacing(cm)					
5	52.05[c]	113.15[c]	40.71	198.74[a]	135.99[a]
10	53.40[b]	113.55[bc]	39.91	141.50[b]	102.21[b]
15	54.51[a]	114.37[ab]	40.44	110.24[c]	74.34[c]
20	54.74[a]	115.28[a]	40.12	86.61[d]	59.99[d]
LSD (5%)	0.68	1.03	NS	12.18	7.14
CV (%)	3.86	2.75	6.92	27.63	23.37

DF= days to 50% flowering, MD=days to 50% physiological maturity, PH= plant height, PSCE= stand count at emergence, PSCH= plant stand count at harvest, NS= non-significant at 5%, N= natoli variety and H= Habru variety

3.2 Growth Parameters

3.2.1 Plant height at maturity

The main effect of chickpea varieties was not significant (P<0.001) effects on plant height. Main effect of inter- and intra-row spacing's had not significant (P<0.05) effect but their interaction had highly significant effect on plant height of the chickpea crop (Table 3). The interaction of 40 cm inter- and 5 cm intra- row spacing resulted in significantly taller plants (42.51 cm) while, the plants in 20 cm inter-and 5cm intra-row and 40 cm inter- and 10cm intra- row spacing's were the shortest in height (38.83 cm) and (39.3 cm) respectively (Table 4). These result might be due to the fact that as the spacing between plants decreased the inter-plant competition for light increased while, sparsely populated plants intercepted sufficient sunlight that enhanced the lateral growth. In agreement with this, Shamsi and Kobraee (2009) who worked on spacing experiment on soybean observed that increasing the density of plants led to significant increases in plant height. In contrast, Shahein *et al.* (1995) reported that plant height was not affected by increasing plant density of faba bean.

3.2.2 Plant Stand count at emergence

Analysis of variance revealed highly significant (P<0.01) effect of the main effects of inter- and intra- row spacing's and non-significant effect of their interaction on Plant Stand count at emergence. Natoli was more densely populated than Habru at emergence. The dense plant population was obtained from the lowest inter-row spacing (20 cm b/n rows) followed by 30 and 40 cm inter row spacing's. Similarly plant population at emergence increased as the intra-row spacing decreases (Table 3).

3.2.3 Plant Stand count at harvest

The mean stand count of chickpea is indicated in Table 1. The main effects of inter- and intra- row spacing showed significant effects on stand count of chickpea at harvest while, the interaction effect of inter-row and intra- spacing was not significant (P>0.05) (Table 3). This indicates that each treatment had significant influence on plant population and development for the crop after establishment. The higher plant stand count (96.95) was recorded from Natoli variety while the lower stand count (89.25) was recorded from Habru variety. This might indicate uniformity in stand establishment of chickpea might be influenced by genotype which may relate to germination quality of varieties.

Table 2: Main effects of Variety, inter- and intra- row spacing on the number of pods per plant, number of seeds per pod, hundred seed weight (g), dry biomass, grain yield and straw yield of chickpea.

Treatments	NPP	NSP	HSW (g)	BM (t/ha)	SY (t/ha)	HI
Varieties						
N	37.33[a]	1.19	28.69[b]	3.97[a]	1.82[a]	44.72[a]
H	33.53[b]	1.18	32.04[a]	3.74[b]	1.58[b]	42.16[b]
LSD (5%)	1.71	NS	0.42	0.16	0.08	1.18
Inter-row spacing(cm)						
20	34.99	1.19	30.30	3.96[a]	1.73[a]	43.01
30	35.22	1.19	30.47	3.90[a]	1.72[ab]	43.52
40	36.08	1.18	30.31	3.69[b]	1.64[b]	43.78
LSD (5%)	NS	NS	NS	0.20	0.09	NS
Intra-row spacing(cm)						
5	29.62[c]	1.18	30..95[a]	4.35[a]	1.86[a]	42.68[b]
10	34.78[b]	1.19	30.33[ab]	3.88[b]	1.72[b]	43.58[ab]
15	37.65[a]	1.19	30.25[b]	3.65[bc]	1.64[bc]	44.37[a]
20	39.69[a]	1.19	29.92[b]	3.53[c]	1.57[c]	43.58[ab]
LSD (5%)	2.58	NS	0.63	0.23	0.11	1.67
CV (%)	22.20	9.05	6.36	18.37	19.59	11.73

NPP= number of pods per plant, NSP= number of seeds per pod, HSW= hundred seed weight, BM= dry biomass, SY= seed yield, STY= straw yield, NS= non-significant at 5%, N= natoli variety and H= Habru variety

3.3 Yield components

3.3.1 Number of pods per plant

Chickpea varieties were significantly (P<0.05) different in number of pods per plant (Table 2). Higher number of pods per plant (96.95) was recorded from Natoli variety. Lower number of pods per plant (89.25) was recorded from Habru variety. The main effects of inter- and intra- row spacing's on the number of pods plant^{-1} were highly significant (p<0.01) but their interaction was not significant (P<0.01) (Table 3). The highest number of pods plant^{-1} was obtained with the interaction effect of 40 cm inter- and 20 cm intra- row spacing's. In general, the number of pods plant^{-1} increased with the increase in inter row spacing at the same level of intra row spacing. The lowest number of pods plant^{-1} was found in the closest spacing, i.e. 30 cm inter- and 5 cm intra-row spacing which was significantly lower than the other interactions (Table 4).

The difference among the inter row spacing in response to intra row spacing on number of pods might be due to the fact that, as the plant population increased there was high competition for the growth factors as compared to wider spacing which had an impact on the number of pods per plant. The reduced competition for light and reduced overlapping from

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adjacent chickpea plants could have enabled the plants grown at wider spacing to utilize its energy for more branching (Table 2) and subsequently, the greater number of pods plant-1. In agreement to the present result, Khan et al. (2010) reported higher number of pods plant^{-1} in the wider inter row spacing of chickpea.

3.3.2 Number of seeds per pod

The mean number of seeds per pod was not significantly different among varieties of chickpea varieties (Table 2). The analysis of variance showed no significant (P<0.01) effect of the main effects of inter - and intra- row spacing and also their interaction had no significant effect on the number of seeds pod^{-1} (Table 3). Yet, whole plant growth and competitive ability depends not only on the photosynthetic rate of individual leaves, but also on the geometry and dynamics of a plant's canopy, and the pattern of energy allocation among all organs (Bange and Caton, 2006).

3.3.3 Dry biomass yield (t ha^{-1})

The mean dry biomass yield of chickpea varied significantly (P<0.001) among the varieties (Table 2). Significantly higher mean value of dry biomass yield (3.97 tons ha^{-1}) was obtained from Natoli variety whereas; the lowest mean value of dry biomass yield (3.74 t ha^{-1}) was obtained from Habru variety.

The main effects of inter- row and intra- row spacing showed a significant (P<0.05) effect on dry biomass. While, the interaction effect of inter row- and intra row-spacing had not significant (P<0.05) effect (Table 3). The highest above ground dry biomass (4.35 t ha^{-1}) was recorded at (5 cm) intra- spacing and the lowest dry biomass (3.53 tons ha^{-1}) was recorded at 20cm intra-spacing (Table 2). For all of the inter row spacing, the highest number of above ground dry biomass were recorded as the intra- row spacing decreased. Solomon (2010) reported that dry biomass per ha was significantly increased with increased plant density (40 cm ×10 cm) on haricot bean. Similarly, Solomon (2010) reported that increment of total dry biomass with increasing plant population of soya bean up to a certain point and subsequently no addition in biological yield can be obtained decrease in economic yield.

3.3.4 Seed yield (t ha^{-1})

The mean grain yield of chickpea varied significantly (P<0.001) among the varieties. The main effects of intra- spacing's showed a highly significant (P<0.01) effect on grain yield (Table 3) while effects of inter- spacing's and their interaction are not significantly affecting yield. The interactions of 30 cm inter- and 5 cm intra- row spacing resulted in the highest grain yield (1.95 ton ha^{-1}). The lowest grain yield (1.51 ton ha^{-1}) was recorded with the interaction of 30 cm × 20 cm (Table 4). The possible reason could be that, when inter-and intra- row spacing was decreased, the number of plants per unit area increased, resulting in higher yield. Biabani (2011) reported higher grain yield of chickpea at average (45cm×7.5cm) spacing combination than 35cm×5cm and 55cm×10cm spacing combinations. This result was also in agreement with Singh and Singh (2002) who reported that the yield per unit area was increased with increasing plant density due to efficient utilization of growth factors.

3.3.5. Harvest Index

The main effects of inter row spacing, intra row spacing and their interaction were showed non-significant differences on mean harvest index of chick pea (Table 3). The highest mean harvest index (45.45%) of chick pea was obtained from the interaction of 40 x 15 cm inter and intra row spacing. The lowest harvest index (42.08 %) of chick pea was obtained with the narrowest inter- and intra- row spacing, i.e. 20 × 10 cm. This reduction in harvest index in narrower spacing might be due to the higher plant population per unit area which might have increased the flower abortion due to competition for nutrients, moisture and solar radiation. Similarly, Chala *et al*, 2020 reported that the maximum harvest index (34.03%) in the widest row spacing (40 cm) of chickpea than 20 cm row spacing.

3.3.6 Hundred Seed weight

The mean hundred seed weight was highly significantly (P<0.001) different among the chickpea varieties (Table 3). Significantly higher mean values of hundred seed weight (32.04 g) was recorded from Habru variety, whereas, the lowest average thousand grain weight (28.69 g) was obtained from Natoli variety. This might be due to the fact that Habru variety is larger in seed size as compared to the other varieties.

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The main effects of intra- row spacing's were significant (P<0.05) while effects of inter row spacing's were not significant, and their interaction had no significant effect on the hundred seed weight of chickpea (Table 3). The highest hundred seed weight (30.95g) was observed with 5 cm intra- row spacing which had no significant difference with 10 cm intra-row spacing (Table 2). In agreement with the result obtained, Lemlem (2011) obtained no significant effect of plant density on hundred- seed- weight of soya bean. In contrast to this result, Khan *et al.* (2010) reported higher hundred seed weight (29.87g) in the wider inter row spacing of 45 cm than 30 cm inter row spacing of chickpea.

Table 3: Analysis of variance for grain yield and other agronomic traits of chickpea as affected by inter- and intra-Row spacing's

Source of variation	Df	PSCE	DF (days)	MD (days)	NPP	NSP	PSCH	PH (cm)	BM (t/ha)	SY (t/ha)	HI	HSW (g)
Var	1	6612.50*	1212.78**	624.22**	1037.40^{ns}	0.01^{ns}	4262.72**	4.99^{ns}	3.82**	4.07**	472.60**	809.7**
Inter	2	32424.20**	31.79**	53.02**	31.34**	0.00^{ns}	14192.32**	5.78^{ns}	2.02*	0.26^{ns}	14.68^{ns}	0.86^{ns}
Intra	3	169371.6**	108.63**	63.75**	1375.43**	0.00^{ns}	80989.35**	8.88^{ns}	9.56**	1.12**	37.46^{ns}	13.49*
year	1	41712.35**	5330.28**	23400**	776.18**	0.02^{ns}	20638.35**	909.87**	95.73**	14.81**	93.01^{ns}	135.4**
Inter*Intra	6	2778.07^{ns}	2.80^{ns}	16.37^{ns}	50.55^{ns}	0.01^{ns}	665.86^{ns}	35.95**	1.04^{ns}	0.22^{ns}	11.87^{ns}	1.40^{ns}
Inter*Var	2	385.07^{ns}	3.04^{ns}	11.48^{ns}	25.07^{ns}	0.00^{ns}	782.52^{ns}	5.76^{ns}	2.19*	0.73**	23.37^{ns}	2.52^{ns}
Intra*Var	3	883.16^{ns}	6.92^{ns}	7.47^{ns}	102.78^{ns}	0.01^{ns}	606.37^{ns}	95.10**	0.35^{ns}	0.14^{ns}	76.44*	4.90^{ns}
year*inter	2	746.19^{ns}	2.79^{ns}	19.19^{ns}	24.86^{ns}	0.01^{ns}	1861.67*	7.09^{ns}	0.21^{ns}	0.11^{ns}	13.32^{ns}	1.29^{ns}
year*Var	1	2200.06^{ns}	302.17**	74.01**	100.82**	0.01^{ns}	2005.56*	3.85^{ns}	0.34^{ns}	0.06^{ns}	1.02^{ns}	38.21**
year*inter*Var	2	664.94^{ns}	2.06^{ns}	2.44^{ns}	106.60^{ns}	0.02^{ns}	589.40^{ns}	13.86^{ns}	0.18^{ns}	0.11^{ns}	5.59^{ns}	1.40ns
year*intra	3	436.45^{ns}	10.79^{ns}	7.81^{ns}	71.13^{ns}	0.01^{ns}	7568.87**	5.47^{ns}	2.34**	0.92^{ns}	71.91*	15.25**
year*intra*Var	3	139.23^{ns}	2.99^{ns}	1.25^{ns}	21.72^{ns}	0.02^{ns}	398.54^{ns}	1.28^{ns}	0.45^{ns}	0.35^{ns}	86.15*	15.78**
Rep(year*Loc)	8	2177.33^{ns}	4.95^{ns}	10.48^{ns}	42.79^{ns}	0.04**	643.49^{ns}	21.11**	5.18**	1.24**	77.67**	2.32ns
Loc(year)	2	163331.81**	1320.53**	17532**	503.91**	0.15**	87107.57**	1020.4**	291.47**	67.13**	712.98**	370.3**
Loc*inter(year)	4	6935.35**	2.04^{ns}	3.43^{ns}	69.70^{ns}	0.02^{ns}	980.98^{ns}	2.99^{ns}	0.49^{ns}	0.09^{ns}	3.11^{ns}	9.46*
Loc*intra(year)	6	14992.35**	6.03^{ns}	28.79**	457.69**	0.01^{ns}	1259.72*	4.89^{ns}	0.92^{ns}	0.21^{ns}	29.12^{ns}	4.29^{ns}
Loc*Var(year)	2	6175.90*	156.05**	195.28**	124.00^{ns}	0.02^{ns}	1887.14*	126.8**	1.01^{ns}	1.50**	218.92**	12.85*
Loc*inter*Var(year)	4	3053.92^{ns}	2.58^{ns}	12.55^{ns}	23.39^{ns}	0.01^{ns}	1178.73*	14.11^{ns}	0.25^{ns}	0.10^{ns}	19.92^{ns}	0.54^{ns}
Loc*intra*Var(year)	6	186.04^{ns}	6.25^{ns}	1.49^{ns}	83.88^{ns}	0.01^{ns}	778.68^{ns}	22.76**	0.69^{ns}	0.21^{ns}	6.43^{ns}	2.57^{ns}
error	226	1376.28	4.29	9.82	6.87	0.01	473.28	7.79	0.50	0.11	25.95	3.73

* *P*< 0.05; ** *P*< 0.01; NS= non-significant at 5%, Df= degree of freedom, DF= days to 50% flowering, MD=days to 50% physiological maturity, PH= plant height, PSCE= plant stand count at emergence, PSCH= plant stand count at harvest, NPP= number of pods per plant, NSP= number of seeds per pod, BM= dry biomass, SY= seed yield, HI= Harvest Index, HSW= hundred seed weight.

Table 4: Mean values of treatments) combinations of yield, growth and growth parameters of chickpea affected by inter- and intra-Row spacing's

Inter	Intra	PSCE	DF	MD	NPP	NSP	PSCH	PH (cm)	BM t/ha	SY t/ha	HI	HSW (g)
20	5	229.50	51.00	112.29	28.60	1.18	142.04	38.83	4.15	1.76	42.44	31.05
20	10	167.33	53.29	112.38	33.98	1.21	114.25	39.75	4.04	1.74	42.08	30.26
20	15	117.33	54.00	115.21	38.12	1.20	84.79	40.49	3.90	1.76	43.94	30.20
20	20	99.21	54.25	114.67	39.27	1.18	71.58	41.12	3.77	1.67	43.58	29.69
30	5	195.79	52.33	112.63	27.97	1.21	143.13	40.79	4.56	1.95	42.88	30.98
30	10	140.71	53.08	113.42	34.88	1.19	108.79	40.69	3.96	1.80	43.36	30.23
30	15	110.38	54.42	113.71	38.51	1.18	78.38	40.40	3.72	1.63	43.71	30.65
30	20	84.29	54.63	115.00	39.53	1.18	55.92	39.31	3.38	1.51	44.12	30.03
40	5	170.92	52.83	114.54	32.29	1.15	122.79	42.51	4.35	1.87	42.73	30.83
40	10	116.46	53.83	114.88	35.42	1.18	83.58	39.30	3.63	1.61	43.89	30.49
40	15	103.00	55.13	114.21	36.32	1.20	59.54	40.42	3.33	1.53	45.45	29.91
40	20	76.33	55.33	116.17	40.28	1.22	52.46	39.93	3.44	1.53	43.05	30.03

DF= days to 50% flowering, MD=days to 50% physiological maturity, PH= plant height, PSCE= plant stand count at emergence, PSCH= plant stand count at harvest, NPP= number of pods per plant, NSP= number of seeds per pod, BM= dry biomass, SY= seed yield, HI= harvest index, HSW= hundred seed weight.

3.3.7. Correlation of yield and yield components of chick pea

Number of pods per plant was significantly ($P<0.001$) and negatively associated to plant stand count at harvest (-0.93), hundred seed weight (-0.81), dry biomass (-0.81) and seed yield (-0.76) (Table 5). There was no significant and positive association with number of seeds per pod and harvest index. Significantly, higher and positive correlation coefficients were observed between plant stand count at harvest with seed yields (0.89), hundred seed weight(0.64), and dry biomass (0.98) (Table 5). A negative correlation coefficient was observed between the number of seeds per pods with plant stand count at harvest (-0.16), plant height (-0.35), hundred seed weight (-0.28), dry biomass (-0.16) and seed yield, (-0.95). Significantly positive associations between dry biomass weight with plant stand count at harvest (0.93) and hundred seed weight (0.73). In conclusion, the yield and yield component of chickpea had a positive relationship with grain yield of chickpea indicated that yield components of chickpea directly influenced the grain yield of chickpea.

Table 5: Correlation matrix of yield and yield component of chickpea

	PSCE	DF	MD	NPP	NSP	PSCH	PH	HSW	BM	SY	HI
PSCE	1										
DF	-0.96^{**}	1									
MD	-0.82^{**}	0.75^{**}	1								
NPP	-0.95^{**}	0.89^{**}	0.77^{**}	1							
NSP	-0.15^{ns}	0.26^{ns}	-0.03^{ns}	0.10^{ns}	1						
PSCH	0.97^{**}	-0.95^{**}	-0.78^{**}	-0.93^{**}	-0.16	1					
PH	0.01^{ns}	0.03^{ns}	0.13^{ns}	-0.03^{ns}	-0.35	0.14^{ns}	1				
HSW	0.81^{**}	-0.78^{**}	-0.56^{**}	-0.81^{**}	-0.28	0.81^{**}	0.01^{ns}	1			
BM	0.85^{**}	-0.83^{**}	-0.62^{*}	-0.81^{**}	-0.16	0.93^{**}	0.39^{ns}	0.73^{**}	1		
SY	0.78^{**}	-0.77^{**}	-0.57^{ns}	-0.76^{**}	-0.13	0.89^{**}	0.48^{ns}	0.64^{*}	0.98^{**}	1	
HI	-0.65^{*}	0.65^{*}	0.48^{ns}	0.51^{ns}	-0.01	-0.69^{*}	-0.02^{ns}	-0.52^{ns}	-0.69^{*}	-0.59^{*}	1

4. SUMMARY AND CONCLUSIONS

Chickpea is the world's second most important grain legume after common bean (*Phaseolus vulgaris* L.) It is an important source of human food and animal feed. One of the factors that influence the quality seeds produced by farmers is plant population. Increasing plant population above the recommended level reduces individual seed size due to increased competition for the same resource. The seed rate recommendation on chickpea so far is for seed production only while the seed multiplication factor is substantially affected by the amount of seed sown. In view of this, the field experiments were carried out at the Debre Zeit Agricultural research center and its sub-site (Akaki) in the 2015 and 2016 main cropping season to investigate the effects of seed rate and plant spacing on seed multiplication factor, seed quality and economic return of chickpea seed production and to determine the appropriate intra and inter row spacing for chickpea seed production

The treatments include two chick pea varieties (Natoli and Habru), four level of intra row spacing (5, 10, 15 and 20cm) and three levels of inter row spacing (20, 30 and 40cm). The experiment was laid out in a randomized complete blocked design with three replications. The mean number of pods per plants was significantly affected by inter-row and intra-row spacing. The highest above ground dry biomass (4.35 kg ha^{-1}) was recorded at (5 cm) intra- spacing and the lowest dry biomass (3.53kg ha^{-1}) was recorded at 20cm intra-spacing. Thousand seed weight of chick pea was significantly improved with inter- and intra-row spacing. The interaction of 30 cm inters and 5 cm intra- row spacing resulted in the highest seed yield (1.95 kg ha^{-1}). The lowest grain yield (1.51 kg ha^{-1}) was recorded with the interaction of 30 cm × 20 cm. Significantly improved mean harvest index and higher (45.45%) of chick pea was obtained from 40 cm inter- and 15 cm intra row spacing. Thus, 40 cm inter-row with 15 cm intra-row spacing can tentatively be recommended as best for production of chickpea in the study area as compared to the current recommendation of 30 x 10 cm.

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