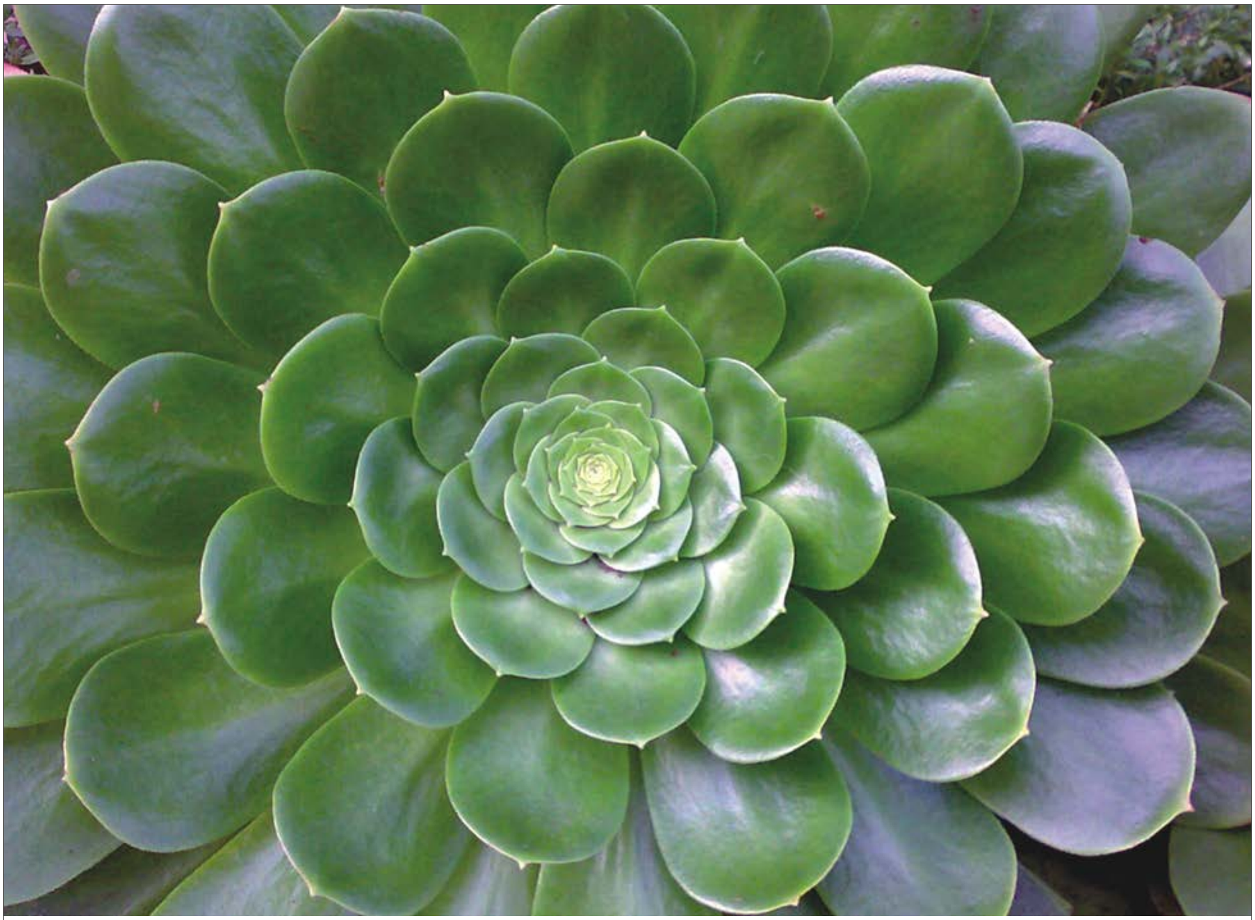

Journal of

Plant Sciences

ISSN 1816-4951

Academic
Journals Inc.

www.academicjournals.com

OPEN ACCESS Journal of Plant Sciences

ISSN 1816-4951
DOI: 10.3923/jps.2020.48.53

Research Article
Seed Rates and Row Spacing on Yield and Yield Components of Linseed: The Case of Dabat District of North Western Ethiopia

Mequanint Teshome, Daniel Tadesse and Yenus Ousman

Department of Plant Sciences, College of Agriculture and Environmental Sciences, University of Gondar, Gondar, Ethiopia

Abstract
Background and Objective: The area coverage and productivity of linseed decreased from time to time even there is no crop package and recommended row spacing and seed rate at regional level due to lack of attention by researchers and also by farmers. The objective of this study is, therefore, to evaluate the effects of row spacing and seed rate on yield and yield components of linseed. **Materials and Methods:** A field experiment was carried out to evaluate the effects of seed rate and row spacing on the yield and yield components of linseed, during 2017/2018 cropping season at Dabat district of Northwestern Ethiopia. KULUMSA1 (CHILALO) was used as test crop. Factorial combinations of three-row spacing, (20, 25 and 30 cm) and three seed rates, (40, 45 and 50 kg) were laid out in RCBD with 3 replications. Data regarding different parameters were recorded. **Results:** The main effect of seed rate was highly significant for days maturity, thousand seed weight and harvest index. Moreover, it was significant for days to flower and number of capsules per plant. The main effect of row spacing was significant for days to maturity. The interaction of seed rate and row spacing were highly significance for a number of primary branches per plant and seed yield. Highest seed yield (1771 kg ha^{-1}) was obtained at seed rate of 40 kg ha^{-1} with 25 cm of row spacing Therefore, seed rate of 40 kg ha^{-1} with 25 cm of row spacing are recommended to increase yield and yield components. **Conclusion:** In conclusion, the effect of seed rate and row spacing affects the important yield components of linseed.

Key words: Linseed, row planting, seed rate, seed capsule, biomass yield and maturity rate

Citation: Mequanint Teshome, Daniel Tadesse and Yenus Ousman, 2020. Seed rates and row spacing on yield and yield components of linseed: The case of dabat district of North Western Ethiopia. J. Plant Sci., 15: 48-53.

Corresponding Author: Daniel Tadesse, Department of Plant Sciences, College of Agriculture and Environmental Sciences, University of Gondar, Gondar, Ethiopia

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Agriculture is the dominant sector for the economy of Ethiopian. It is a means of subsistence for more than 85% of the country's rural population, contributes more than 50% of the national GDP, 90% export earnings and provides employment for 88% of the labor force[1].

Oilseeds are the second export products next to coffee and already more than 3 million small holders are involved in their production[2]. Linseed, *Linum usitatissimum* L., is an oil seed crop in the family Linaceae. Evidence of use by human's dates back to about 8,000 B.C. in the Fertile Crescent[3,4].

In Ethiopia, linseed has been cultivated for two primary purposes, seed and oil use. It has traditionally been used for food and as a cash crop since ancient times[5]. It is now grown primarily for food and to generate revenue, either in local markets or by export. For food, the seeds are usually roasted, ground, mixed with spices and water and served with various local bread. It is also consumed in soups, with porridges and cooked potatoes, etc. Limited amounts are also pressed locally for its edible oil, which is often blended with other high-quality vegetable oils[6] and it is widely cultivated in higher elevations of Ethiopia where frost is a threat for other oilseeds[7].

Ethiopia is the fifth largest producer of linseed in the world next to Canada, China, USA and India[3]. In 2016/2017, Ethiopia allocated 81,575.75 ha of land for linseed and produced 902,761.25 quintals[8]. Likewise, Amhara region contribute 21,782.47 ha (26%) of land and the yield was 150,400.08 quintals (16%) while North Gondar had 4,613.63 ha and production were 38,102:83 quintals of linseed was obtained. In other words, 21% of the areas allocated for linseed production in Amhara Region and 5% of the areas allocated for linseed production in the country as a whole had come from North Gondar Zone. Besides 25% of total linseed production in Amhara region and 4% of linseed production in Ethiopia was obtained from this zone. The productivity of the crop at national, Amhara region and North Gondar were 11.07, 6.9 and 8.258 q ha^{-1}, respectively[8].

Despite numerous uses of linseed, large areas allocation and many years of production, tradition linseed productivity is very low in Ethiopia (1.1 t ha^{-1})[8]. The production in Ethiopia is characterized by low input, low yield and poor product quality mainly due to attitude and poor management practices such as lack of proper weed management system, poor seed and field hygiene, poor seedbed preparation, inadequate plant nutrition, inappropriate seeding rate, improper threshing ground and improper cleaning. On the other hand, using improved varieties along with good agronomic practices gave as high as 2.2 t ha^{-1} on research fields and some model farmers managed to produce as high as 2.0 t ha^{-1} when supported with improved seed of linseed, intensive training and close supervision[9].

Currently, there is a huge shortage of edible oil in the country[10]. Hence, concerted research, development and promotion efforts are needed, at all levels, in order to reverse the current situations. The objective of this study is, therefore, to evaluate the effects of row spacing and seed rate on yield and yield components of linseed.

MATERIALS AND METHODS

Experimental site: The experiment was conducted in Dara Kebele during 2017/2018. The site is found in Dabat district which about 75 km away from Gondar town north of Gondar town in. It is about 255 km North-West of Bahir dar located in one of the high altitudes and high rainfall area of the Amhara National Regional state. The district has latitude of about 12.9814°N and longitude of 37.7623°E. The altitude of the woreda ranges from 1500-3200 (m.a.s.l). Mean annual rainfall in the district ranges from 800-1400 mm. The main rainy season starts at the beginning of June and continues up to the end of September. The minimum and maximum daily temperature of Dabat is 18 and 35°C, respectively.

Experimental design and procedures: The designs were factorial RCBD of three replications, factorial combinations of three-row spacing (20, 25 and 30 cm) and 3 seed rates (40, 45 and 50 kg ha^{-1}). Size of the plot was 3×2 m (6 m^2). Spacing between plots (path) was 50 cm, it had drainage furrow between plots and between replications spacing between blocks was 200 cm. Sowing was done first week of July fertilizer were applied at the rate of 23 kg ha^{-1} P_2O_5 that was applied during sowing while N 23 kg ha^{-1} applied one third at sowing and the remaining applied after 35 days to sowing. The fertilizers used were urea (46% N) and TSP (46% P_2O_5), used as a source of nitrogen and phosphorus, respectively.

Data collection: Data were collected on different parameters from the net plot area. The net plot area was delineated by leaving two boarder rows at both sides of every plot and 0.5 m at both ends of each row as the row spacing varied the net plot area also varied. Therefore, the corresponding net plot area for row spacing of 20, 25 and 30 cm was 1.5×2.6, 1.5×2.5 and 1.5×2.4 m, respectively.

At full maturity stage, 5 plants were taken at random from each plot to estimate plant height (cm), number of primary and secondary branches per plant, number of capsules per plant, 1000-seed weight (g), seed yield and biological yield. Straw yield/ha was estimated from the central area of the respective net plot area, plants were harvested, tied and left to dry, thereafter, it was threshed to remove the capsules and weighted to determine seed yield and straw yield per net plot area and then converted yield in kg ha^{-1} after cleaned from straw and other residuals and weighed to the nearest gram and converted to record seed yield in kg ha^{-1}.

Data analysis: Data normalization test for all phonological, growth and yield components done by SAS software[11]. Then variance analysis and all data were subjected to statistical analysis by the technique of analysis of variance of the factorial experiments in randomized complete block design[12]. Combined analysis of both seed rate and row spacing was done. Main effects and interactions were tested by using the error terms appropriate for the design. Treatment means were compared at 5% level of probability by using the Least Significant Difference (LSD) method.

Table 1: Main effects of seed rates and row spacing on days to 50% flowering, days to 90% maturity and plant height

Seed rate	Days to 50% flowering	Days to 90% maturity	Plant height
40	72.2^{a}	138.22^{a}	72.93^{a}
45	66.56^{b}	137.78^{a}	76.56^{a}
50	63.11^{c}	133.56^{b}	83.67^{a}
LSD (5%)	2.39	1.99	NS
Row spacing			
20	65.13^{b}	135^{b}	77.33^{a}
25	67.67^{a}	136.13^{b}	78.27^{a}
30	67.8^{a}	138.2^{a}	77.54^{a}
LSD (5%)	2.4	1.99	NS
CV (%)	3.4	1.4	16.05
Mean	66.96	136.52	77.72

CV: Coefficient of variance, LSD: Least significant difference, a, b, cMean

Table 2: Interaction effects of seed rates and row spacing on primary branches

	Seed rate		
Row spacing	40	45	50
20	5523.9^{d}	6140^{cd}	5466.3^{d}
25	7575.5^{b}	6266^{c}	7448^{b}
30	7582.8^{b}	7716^{ab}	8055^{ab}
Mean	7175.46		
LSD (5%)	755.91		
CV (%)	6.25		

CV: Coefficient of variance, LSD: Least significant difference, a,b,c,dMean

RESULTS AND DISCUSSION

Days to 50% flowering: The analysis of variance for days to 50% flowering revealed that it was significantly affected by the main effects of row spacing and also seed rate, but there is no significant effect on interaction effects (Table 1). Concerning to seed rates the more the seed rate the lesser the days to flower 50 kg ha^{-1} required (63.11) days to flower this could be when the plant population increases there is a series competition for nutrient, light and water as escaping mechanism they fasten their flowering period. Whereas, seed rate 40 kg ha^{-1} needs more time to flower (72.2). This could be relative there is less competition to the resources it should not goes forced early flower due to a smaller number of plant population in a unit area. Similar reports indicated that there is significant ($p \leq 0.05$) main effects of seed rate occurred on days to flowering of linseed[13]. On the other hand, row spacing significantly affects days to 50% flowering the narrow spacing (20 cm) flower early (65.13) days, while wider spacing showed late-flowering 30 cm needs (67.8) days because it can get more light, water and nutrient relatively than the rest 2 spacings.

Days to 90% maturity: Days to 90% physiological maturity were affected by the main effects of row spacing and seed rate but not interaction effects there is significant ($p \leq 0.05$) on days to 90% maturity on both main effects of seed rates and row spacing. On seed rate bases 40 kg ha^{-1}, it requires more times than the other two seed rates (138.22). Whereas, the higher seed rate needs shorter time to flower (133.56) days, this might be there is a series competition in higher population than the lower one. Based on row spacing 20 cm mature earlier than the other 2 spacing, which is 30 cm required delayed maturity, because there is relatively lesser competition to water, nutrient and aeration. Table 1 illustrated the significance of 90% physiological maturity.

Plant height: Analysis of variance revealed that plant height was affected neither by the main effects of row spacing and seed rate nor by their interaction (Table 1). This could be due to more competition for sunlight. Similar reports indicated that seed rates had no significant effects on plant height, spikes/m^{2} and 1000-seed weight[14]. Table 1 Illustrated the significance of plant height on both seed rates and row spacing of linseed.

Number of primary branches: The interaction effects of seed rate and row spacing revealed a significant influence on the number of primary branches (Table 2). At both seed rate and row spacing, there was an increased in the number of primary branches with increase row spacing, i.e., number of primary branches was increased in-row spacing. The highest number

Table 3: Main effects of secondary branches, number of seeds per capsule and number of capsules per plant

Seed rate	NSBR	N of seed/plant	NCP
40	6.17[a]	9.4[a]	19.81[a]
45	4.84[b]	6.02[c]	14.67[b]
50	3.14[c]	7.89[b]	9.11[c]
LSD (5%)	1.36	1.41	3.55
Row spacing			
20	3.9[a]	7.69[a]	11.89[b]
25	4.93[a]	7.84[a]	16.71[a]
30	5.18[a]	7.78[a]	14.68[ab]
LSD (5%)	1.37	NS	NS
CV (%)	27.89	17.48	23.49
Mean	4.72	7.77	14.53

Mean values in row with same letter are not significantly different (p>0.05), NSBR: Number of secondary branch per plant, NCP: Number of capsules per plant, CV: Coefficient of variance, LSD: Least significant difference, [a,b,c]Mean

of primary branches was obtained at 30 cm×50 kg ha^{-1}, whereas, the lowest number of primary branches was recorded from 20 cm×50 kg ha^{-1}.

The interaction effect of seed rate and row spacing revealed a highly significant (p<0.01) effect on primary branches (Table 2). On the wider row spacing (30 cm) produced a higher number of primary branches that was significantly higher than 20 and 25 cm. On the other hand, at seed rate, higher number of primary branches was recorded due to (50 kg ha^{-1}). Generally, the interaction of seed rate and row spacing, higher number of primary branches was observed at the wider row spacing. This could be possibly due to the availability of growth factors resulted from the heaping of the fertile topsoil, which in turn, increased the lateral vegetative growth of the crop.

Number of secondary branches: The main effect of seed rate indicated that when the seed rate increased from 40-50 kg ha^{-1} the number of secondary branches decreased from 6.17-3.14 and also, on row spacing the number of secondary branches increased as spacing increased (Table 3). The number of secondary branches increased from 3.9-5.18 on the row spacing increased number of secondary branches as increased spacing from 20-30 cm, respectively. Mean performances of spacing indicated that greater numbers of secondary branches were produced at wider row spacing. (Table 3). The spacing of 30 cm produced higher number of secondary branches (5.18). From the result, it can be inferred that wider spacing allows the plant to produce more branches due to higher use of resources.

Number of seeds per capsule: Table 3 illustrated the main effect of seed rate on the number of seeds per capsule of linseed. Seed rate significantly affected by the number of seeds per capsule. The higher mean number of seeds per capsule (9.4) was recorded at seed rate of 40 kg ha^{-1} compared to the other 2 seed rates (6.02) and (7.89) for 45 and 50 kg ha^{-1}, respectively. This could be due to there is relatively enough nutrient, water and aeration enhanced the conversion of solar energy to chemical energy, which might have stored on the seeds. On the other hand, the main effect of row spacing on this parameter showed non-significant.

The present result agreed with that of Singh and Singh[15]. As plant density increases, the amount of dry matter in vegetative parts also increases. Both the biological and economic yields increase with increasing plant population up to a certain point and subsequently no addition in biological yield can be obtained and economic yield decreases.

Number of capsules per plant: The analysis of variance on the number of capsules per plant indicated that the main effect of seed rate had a significant effect on the parameter. Higher mean capsule number per plant (19.81) was observed on the seed rate of 40 kg ha^{-1} as compared to the other two seed rates. There was 19.81 number of capsules per plant when linseed was grown on the seed rate 40 than 50 kg ha^{-1}. This might be due to the number of branches and capsule, which were higher on the 40 kg ha^{-1}. Moreover, the higher number of branches on 40 kg ha^{-1} might lead to a large number of capsules per plant, as photosynthetic surface or vegetative infra-structure before heading or anthesis plays significant role in determining the number of grains per plant. Abd El-Mohsen *et al.*[9] reported that number of capsules per plant has significant difference in number of capsules per plant, this research result also proved Abd El-Mohsen results (Table 3). Higher mean capsule number per plant (19) was observed on the seed rate of 40 a kg ha^{-1} compared to that of 50 kg ha^{-1}. In general, there was an increase in the number of capsules per plant when linseed was grown on the seed rate of 40-50 kg ha^{-1} this result lead to the lesser the seed rate the greater number of capsules per plant.

Thousand seed weight: The analysis of variance on thousand seed weight indicated that the main effect of seed rate had a significant effect on the parameter, but do not have a significant effect on spacing. Njuguna *et al.*[14] reported that seed rates had no significant effects on plant height, spikes/m^2 and 1000-seed weight. But the research conducted disproved Njuguna *et al.*[14] results because under this result 1000 seed weight significant to seed rate it decreases from 5.48 (40 kg ha^{-1}-4.98 (45 kg ha^{-1}) and 4.04-50 kg ha^{-1} thus, indicated that 40 kg ha^{-1} decreases yield, but it does not affect on row spacing (Table 4) illustrated the significance on main effects of seed rate and row spacing.

Table 4: Main effects of 1000 seed weight, biomass yield and harvest index

Seed rate	1000 seed weight	Biomass yield	Harvest index
40	5.48[a]	3120.6[a]	45[a]
45	4.98[b]	3484.7[a]	29[b]
50	4.04[c]	3948.9[a]	22[b]
LSD (5%)	0.35	NS	0.08
Row spacing			
20	4.77[a]	3168.5[a]	31.38[ab]
25	4.96[a]	3789.3[a]	37.88[a]
30	4.77[a]	3553[a]	27.52[b]
LSD (5%)	NS	NS	NS
CV (%)	7.4	27.21	24.32
Mean	4.8	3518	32

Mean values in row with same letter are not significantly different (p>0.05), CV: Coefficient of variance, LSD: Least significant difference, [a,b,c]Mean

Table 5: Interaction effect seed rate and row spacing on seed yield

	Seed rate		
Row spacing	40	45	50
20	1228[b]	1045.3[bc]	831.7[c]
25	1771[a]	888.9[bc]	860[c]
30	1086[bc]	1042[bc]	752[c]
Mean	1056.14		
LSD (5%)	334.46		
CV (%)	19		

Mean values in row with same letter are not significantly different (p>0.05), CV: Coefficient of variance, LSD: Least significant difference, [a,b,c]Mean

Delesa and Choferie[13] conducted research on effects of planting method and spacing on yield of linseed at Kulumsa showed that row spacing has no significant effect on thousand seed weight this result is analogous to the above research.

Biomass yield: The result of the experiment revealed that there was no significant difference in biomass yield per plant due to seed rates, row spacing and interaction of both. Higher dry biomass per hectare was obtained at a higher seed rate of 50 kg ha^{-1} (Table 4). Spacing 25 cm resulted higher dry biomass yield per hectare resulted in greater dry biomass yield/ha.

Harvest index: The analysis of variance on harvest indicated that the main effect of seed rate had a significant effect on the parameter (Table 4). Nevertheless, the main effects of row spacing and the interaction effect had no significant influence on harvest index. When seed rate increases from 40-50 kg ha^{-1} harvest index decline, high harvest index indicated that the crop mobilized large amount of assimilates from the biomass to the seed. As plant density increases, the amount of dry matter in vegetative parts also increases. Both the biological and economic yields increase with increasing plant population up to a certain point and subsequently no addition in biological yield can be obtained and economic yield decreases. Similarly, this research had got the same results because at the seed rate of 40 kg ha^{-1} there is high harvest index it indicated that there is high amount of assimilates goes to at seed rate of 40 kg ha^{-1} gradually decreases as plant population increases.

Seed yield: The interaction effects of seed rate and row spacing revealed a significant influence on seed yield (Table 5). Seed rate, row spacing and interaction of both had significant effect on seed yield of linseed (Table 5). Higher mean seed yield (1771 kg ha^{-1}) was obtained on seed rate of 40 kg ha^{-1} and row spacing 25 cm while the lower mean seed yield (752 kg ha^{-1}) was recorded on seed rate of 50 kg ha^{-1} and row spacing of 30 cm.

The higher seed yield obtained by the interaction of 40 kg ha^{-1} and 25 cm could be probably due to the higher number of branches per plant, number of capsules per plant and higher number of seeds per capsule, which were pre-dominantly associated with row spacing and seed rate.

CONCLUSION AND RECOMMENDATION

An experiment was conducted during 2017/18 main season at the farmer field of Dabat district with the objective of evaluating the effects of seed rate and row spacing on the yield and yield components of linseed. It was shown that there was variability in phenological traits when linseed was planted on different seed rates and row spacing. Variation was observed in plant height, yield and number of secondary branches when the seed rate and row spacings vary. Number of capsules, 1000 seed weight and harvest index were affected by seed rate, but no for the variability in the row spacing.

Numerically, the highest seed yield per hectare was recorded due to the combination of 40 kg ha^{-1} on seed rate and row spacing of 25 cm, but the research is done on one season at one location, required confirmation with further studies to give a valid recommendation.

SIGNIFICANCE STATEMENT

This study discovers that the row spacing and seed rate recommended for the study area and being used by farmers for many years was not benefiting them. From the foregoing results, seed yield can be substantially improved by the use of 40 kg ha^{-1} seed rate and 25 cm row spacing at Dabat district and similar agro-ecological areas.

REFERENCES

1. Fanta, E.G., 2005. The production of oilseeds in Ethiopia: Value chain analysis and the benefit that accrue to the primary producers. Master Thesis, Faculty of Economics and Management Science, University of the Western Cape, South Africa.
2. Wijnands, J.H.M., J. Biersteker and R. Hiel, 2007. Oilseeds business opportunities in Ethiopia. Ministry of Agriculture, Nature and Food Quality, the Netherlands, pp: 1-36. http://library.wur.nl/WebQuery/wurpubs/361069
3. Wakjira, A., 2007. Linseed (*Linum usitatissimum* L.). In: Vegetable Oils and Fats, Plant Resource of Tropical Africa (PROTA), Vandervossen, H.AM. and G.SM. Kamilo (Eds.). PROTA Foundation, Wageningen, Netherlands, pp: 108-115.
4. Vaisey-Genser, M. and D.H. Morris, 2003. Introduction: History of the Cultivation and Uses of Flaxseed. In: Flax, The genus Linum, Muir, A.D. and N.D. Westcott (Eds.). Taylor and Francis, London, pp: 1-21.
5. Seegler, C.J.P., 1983. Oil Plants in Ethiopia, their Economy and Agriculture. In: Farmers Seed and Varieties: Supporting Informal Seed Supply in Ethiopia, Thijssen, M.H., B. Zewde, A. Beshir and W.S. de Boef (Eds.)., Wageningen International, Wageningen.
6. Fikre, M., F. Mekbib and A. Wakjira, 2013. Diversity of Ethiopian Linseed Landraces and Some Exotic Cultivars. Lambert Academic Publishing, Germany.
7. Getnet, A. and A. Nigussie, 1997. Highland oil crops: A three-decade research experience in Ethiopia. Research Report No. 30, Institute of Agricultural Research, Addis Ababa, Ethiopia.
8. CSA., 2016. Agricultural sample survey 2016/17: Area and production of major crops, Meher Season. Volume 1. Central Statistical Agency, Addis Ababa, Ethiopia.
9. Abd El-Mohsen, A.A., A.M. Abdallah and G.O. Mahmoud, 2013. Optimizing and describing the influence of planting dates and seeding rates on flax cultivars under Middle Egypt region conditions. World Essays J., 1: 142-152.
10. PPPO., 2009. Improving the competitiveness of the Ethiopian edible oil sector-policy brief. Public Private Partnership on Oilseeds. Volume 1, No. 1. December 2009. http://eposspea.org/
11. SAS., 2002. SAS System for Windows Release 9.2. SAS Institute, Cary, NC, USA.
12. Gomez, K.A. and A.A. Gomez, 1984. Statistical Procedure for Agricultural Research. 2nd Edn., John Wiley and Sons, New York, USA., ISBN: 0471870927, Pages: 704.
13. Delesa, A. and A. Choferie, 2015. Response of linseed (*Linum usitatissimum* L.) to seed rates and seeding methods in South-Eastern highlands of Ethiopia. J. Glob. Innov. Agric. Soc. Sci., 3: 58-62.
14. Njuguna, M.N., M. Munene, H.G. Mwangi, J.K. Waweru and T.E. Akuja, 2010. Effect of seeding rate and nitrogen fertilizer on wheat grain yield in marginal areas of Eastern Kenya. J. Anim. Plant Sci., 7: 834-840.
15. Singh, N.P. and R.A. Singh, 2002. Scientific Crop Production. 1st Edn., X Press Graphics, Delhi, India.