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EFFECTS OF SPACING ON YIELD OF MUNG BEAN (*VIGNA RADIATA* L.) IN JILE TIMUGA DISTRICT, NORTH-EASTERN ETHIOPIA

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KeyWords

Jile Tumugaa, mung bean, plant density, planting space

ABSTRACT

Maintaining optimum planting space is the most important agronomic practice for increasing growth and yield of mung bean. A field trial was conducted to determine the optimum intra and inter-row spacing of mung bean (Vigna radiata L.) at Alala kebele in Jile Timuga District, North-Eastern Ethiopia in 2016 main cropping season. Rasa mung bean variety (N-26) was used as a test crop. Factorial combinations of three intra row spacing (5, 10 and 15 cm) and four inter row spacing (25, 30, 35 and 40 cm) were laid out in a randomized complete block design with three replications. The analysis of variance indicated that most phenological stage and growth parameters of the crop significantly influenced by main effect of intra and inter row spacing. Most yield and yield components parameters were significantly influenced by their interaction effect. Grain yield positively correlated with plant maturity (r=0.44**) and number of seeds per pod (r=0.48**) but negatively to straw yield (-0.57**). Mean separation and economical analysis results indicated that interaction of 10 cm intra row and 30 cm inter row spacing treatment was significantly increased crop seed yield and gave more profit (29375.95 Birr /ha net profit) as compared to the other treatments. Thus, using of 10 x 30 cm spacing is found optimum to improve mung bean production in Jile Timuga district. However, to reach comprehensive conclusion further investigations is required over seasons and locations.

1. INTRODUCTION

Mung bean (*Vigna radiata* L.) commonly known as green gram is an ancient and well-known pulse crop that belongs to family *Papilionoideae* and originated from south East Asia (Mogotsi, 2006). The crop is the most important pulse crop in the world. Mung beans are mainly grown for human food, in the form of boiled dry beans, stew, flour, sprouts and immature pods as a vegetable. The crop is more palatable, nutritive, digestible and non-flatulent than other pulses. Seed of mung bean contains 20-24% protein, 2.1% oil, 1-2% fats and carbohydrates and a fair amount of vitamin A and B (Parviz and Mohammad, 2015). The crop has good nutritive value and reasonable cost for the consumers (Asrate *et al*., 2012; Gebre, 2015). Besides, dry beans are sometimes used for animal food, mainly poultry; when they are either roasted or boiled while its biomass used as fodder (Winch, 2006). Mung bean plant fixing atmospheric N_2 and enriches the soil with N nutrient for the growth of succeeding crops (Parviz and Mohammad, 2015). On the other hand, the crop can be successfully grown on marginal lands where other crops perform poorly and most suitable for green manure use (Ghafoor *et al*., 2003; Dainavizadeh and Mehranzadeh, 2013).
The crop is a short-duration and low input required legume crop. Mung bean is a quick or very early maturing crop, which requires 75–90 days to mature. The crop is resistant to drought and adverse environmental conditions (Kidane, 2010; FDREMoA, 2015; Gebre, 2015). Thus, it is wide environmental adaptability legume crop. Mung bean has special features such as its earliness in maturity, supply good yield, drought resilient property makes highly responsive in scanty rainfall and its ability to stimulate striga without being parasitized (Kidane, 2010). The same source disclosed that the crop is the most suitable crop to put under crop rotation with cereals and relay cropping systems through its compatible feature of effectiveness in residual soil moisture usage.

Mung bean has been grown under small scale farmers of Amhara, Oromiya, Tigray and Benishangul Gumuz Regional State's lowland area. Similarly, Asrate *et al*. (2012) and Gebre (2015) reported the crop is produced in moisture stress areas of Ethiopia. In Amhara Regional State, the crop is widely grown in North Shewa and South Wollo zone.

However, Ethiopian dry lands covers about 75 percent of the total land mass of the country and found in arid, semi arid and dry sub-humid agro-ecologies. It located, geographically in the north, east and central areas of the rift valley, also south and southeastern parts of the country, including a very wide and with diversified ranges of agricultural systems. On the other hand, most portions of the dry lands are categorized under semi-arid agro-ecology that characterized by most suitable area for mung bean production due to short growing cycle of the crop (Kidane, 2010). Thus, the country has great potential for the crop production but very few lands put under mung bean cultivation. According to CSA (2015) report indicated that in 2014/15 cropping season about 14,562 hectares of land was put under cultivation for mung bean in Ethiopia and 14,067.7 t yield obtained meanwhile in the same season 11,281.7 ha cultivated lands of Amhara national Regional State (ANRS) put under mung bean production and about 11,983 t yield obtained. In 2015/16 cropping season in Jile Timuga district about 1,400 ha land was put under mung bean production and 2,100 t yield obtained. According to World Bank (2007) report most citizen of the country has been threatening by food insecurity. Gebre (2015) suggested that an adoption and expansion of mung bean production on moisture stressed areas is crucial to solve food insecurity problem in Ethiopia. Mung bean is the most suitable and recommended pulse crop to improve the nation's food insecurity problem and enhance soil fertility in the Ethiopian low lands. In spite of its importance as food and feed, very little attention has been paid to its quantitative and qualitative improvement in Ethiopia.

Several reports indicated that numerous biotic and abiotic factors are responsible for low coverage and productivity of mung bean in Ethiopia, among these lack of improved varieties, prevalence of disease and pest attack, high intensity of soil salinity problem, impact of climate change and meager information is available on optimum planting space, seed and fertilizer rate (FDREMoA, 2015 and Gebre, 2015).

Numerous conducted studies in another countries indicated that among crop management practices, seeding density of plant population has significantly affect growth and yield of mung bean (Ansari *et al*., 2000; Ihasanullah, 2002; Mohsen and Jahanfar, 2012). Ihsanullah *et al.* (2002) and Kabir and Sarkar (2008) found that planting mung bean on intra-row spacing of 10 cm and inter-row spacing of 30 cm gave 320,000 plants per ha^{-1} which is optimum for commercial cultivation. Besides, planting the crop on various inter-row spacing result indicated that maximum mung bean yield (921 kg ha^{-1}) obtained on narrow inter spacing (20 cm) but minimum yield of 727 kg ha^{-1} recorded on wide inter-row spacing (43 cm) (Bashir, 1994). Moreover, JTDAO (2016) reported that inappropriate sowing method and spacing are bottle neck problems to maximizing mung bean production in Ethiopia. However, FDREMoA (2015) disclosed that intra row spacing of 5 cm and inter row of 25 cm found optimum planting mung bean in short rainfall season (*Belg*) or in moisture scarce areas while during main rainfall season or summer (*Keremt*) optimum yield can be obtained on inter row of 30-40 cm and intra row spacing of 5 cm. However, ANRS Bureau of Agriculture (2015) reported that 40 cm inter row spacing and 10 cm intra row spacing optimum for planting mung bean. Therefore, there is sort of confusion on the information of optimum spacing for mung bean crop in Ethiopia; study area Thus, meager information availability has been hindered to improve mung bean yield in the study area. Hence therefore, this study was designed to achieve the following objectives in the study area:

- To evaluate the effects of spacing on growth and yield of mung bean.
- To determine economically optimum intra-row and inter-row spacing to improve mung bean yield
- To recommend the optimum intra and inter row spacing for mung bean production

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The experiment was conducted at Alala kebele in Jile Timuga district, Oromo Nationality Zone of Amhara National Regional State during the 2016 main cropping season. The site is found at 280 km northeast of Addis Ababa along the highway of Addis Ababa to Dessie. The district lies on geographic coordinate between 10°02′- 10°25′ N of latitude and 39°55′-40°24′ E of longitude at an altitudinal range between 1100 and 2000 masl (Figure 1). The study area is dominantly covered by radish brown color soils with sandy to loam in texture. According to meteorological data of two decades (1997-2016), the area has been received mean annual rainfall of 820 mm and higher in July and August month. In these decades its mean monthly maximum and minimum temperatures were 12.3° C and 30.3° C, respectively.

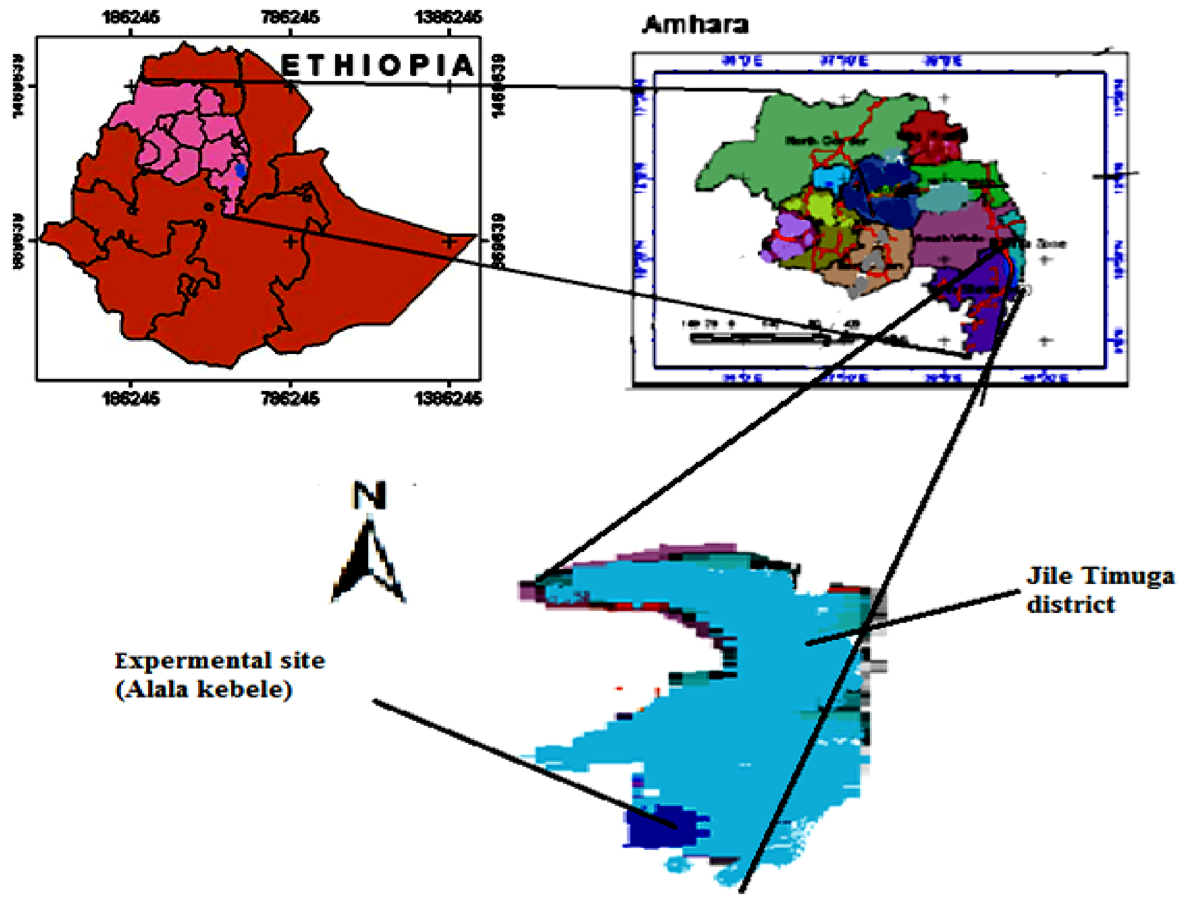

Figure 1. The experimental area map

2.2. Experimental Materials and Treatments

Mung bean *Rasa* (V-26) variety was used as a test crop. NPSB fertilizer (19% N, 37.2% P_2O_5, 6.8 % S and 0.3% B) with 100 kg/ha rate was used as sources of N and P fertilizer. The factorial combinations of three levels of intra row (5, 10 and 15 cm) and four levels of inter row (25, 30, 35 and 40 cm) 12 treatment combinations were used.

2.3. Experimental Design and Procedures

The treatments were laid out in randomized complete block design and replicated three times. The experimental field was tilled three times for fine seed bed preparation. Gross plot size was 1.6 m width and 2 m length (3.2m^2) while a net plot size determined by excluding a border row from each side and 0.5 m row length at both ends to avoid the border effect. The space between blocks and plots were 1 and 0.5 m, respectively. The treatments were randomly allotted to each plot .The crop was planted on August 23, 2016 at 3 cm depth and uniform rate of NPSB fertilizer banded along the crop. All required cultural practices such as weeding, harvesting and trashing that adopted for mung bean productions were implemented according to standard procedures during the experimental season.

2.4. Soil Sampling and Analysis

Ten soil samples were taken at 0-30 cm depth through diagonal method from the experimental field before planting the crop using an auger then it properly mixed to form a composite sample for analysis of selected physicochemical properties of the soil (soil texture, pH, available P, total N, soil texture, organic carbon and cation exchange capacity) at Dessi and Addis Ababa Soil Testing Laboratories. The soil sample was air dried, grinded and sieved size through a 2 mm pore size for the analysis of pH, available P where as, for the determination of total nitrogen and organic carbon the soil was made to pass through 0.5 mm pore size sieve.

Soil pH was determined from the filtered suspension of 1:2.5 soils to water ratio using a glass electrode attach to a digital pH meter. Texture of the soil was analyzed by the hydrometer method (Sahlemedhin and Taye, 2000). Total nitrogen of the soil was estimated by Kjeldhal procedure as described by Jackson, 1967). Available phosphorus was extracted by Olsen *et al*. (1954) procedure and measured using Spectrophotometer. Cation Exchange Capacity (CEC) of the soil was determined from NH_4OAc saturated samples, and measured through distillation using the micro kjeldahl procedure .The organic carbon content of the soil was analyzed following the wet digestion method described by Walkley and Black (1934),

2.5. Data Collection and Measurements

2.5.1. Phenological and growth parameters

Days to 50% emergence: was determined by counting the number of days from sowing to the time when 50% of the plants started to emerge the tip of panicles through visual observation.
Days to 50% flowering: It was recorded by counting the number of days elapsed from the time of planting up to 50% of the plants in the plot produced flowers.
Days of 90% physiological maturity: it was recorded when 90% of the plants in each plot reaches physiological maturity.
Plant height: The average height of ten plants which are selected randomly measured in centimeters from the base to tip of a plant excluding owns from the net plot area of each plot at harvest. Average plant height for each plot was calculated.

2.5.2. Yield and yield components

Pod number: The total numbers of pods were counted from randomly selected two plants from the plants grown on net plot area's 0.5 m length.
Seed number per pod: The number of seed per pod was counted from randomly selected ten plants at the inner rows of each plot from each treatment.
Thousand seeds weights: It is the weight of 1000 seeds from a randomly sampled from net plot's yield. Samples of thousand grains were taken at random from each plot.
Biomass yield: Total biomass or biological yield was measured by weighing the sun dried total above ground plant biomass (straw + grain) of the net all plot.
Grain yield : It was measured by taking the weight of the grains threshed from the net plot area after adjusting the grain moisture content to 12.5% and then converted to kilograms per hectare for data analysis purpose.
Straw Yield: Straw yield was determined after mung bean bundles of each plot were threshed and straw yield recorded by subtracting grain yield from total above ground biomass in kg per plot and then converted into kg per ha.
Harvest Index: is the weight of grain divided by the total weight of above ground biomass of each plot expressed as percentage, and calculated by using the standard formula:

2.6. Statistical Analysis

The data were subject to analysis of variance (ANOVA) following the standard procedure of Gomez and Gomez (1984) using General Linear Model (GLM) procedure of SAS software (SAS Institute Inc, 2002). Significant difference among treatment means was delineated by LSD procedure at 5% level of significance. The correlation analysis was carried out by calculating simple correlation coefficients between yields and yield components.
Economic analysis was conducted through CIMMYT partial budget methodology (CIMMYT, 1988). The dominance analysis procedure, which was used to select potentially profitable treatments, comprised ranking of treatments in an ascending order of total variable cost from the lowest to the highest cost to eliminate treatments costing more but producing a lower net benefit than the next lowest costing treatment. The total variable cost comprised costs of seed and labor.
The average market price of mung bean grain and labor collected from the local market during the experimental season. The price of mung bean seed was 27 Birr per kg at local market. While costs of planting, weeding, harvesting (threshing and winnowing), packaging material and transporting were 900 to 500 Birr per ha, 80 Birr per 100 kg, 7 Birr per 100 kg and 5 Birr per 100 kg, respectively. Following the CIMMYT partial budget analysis method, total variable costs (TVC), gross benefits (GB) and net benefits (NB) were calculated. Then treatments were arranged in an increasing TVC order and dominance analysis was performed to exclude dominated treatments from the marginal rate of return (MRR) analysis in order to recommend economically profitable treatments (CIMMYT, 1988). A treatment is said to be dominated if it has a high total variable cost (TVC) but with lower in net benefit since the net benefit obtained decreased as the cost increased and eliminated by dominance analysis from marginal rate of return (CIMMYT, 1988). A treatment which is non-dominated and having a MRR of greater or equal to 50% and the highest net benefit is said to be economically profitable (CIMMYT, 1988).

3. RESULTS AND DISCUSSIONS

3.1. Physicochemical Properties of Experimental Soil

The laboratory analysis result of the pre-planting soil indicated on Table 1 that soil texture was silt loam. Neutral in reaction with pH of 7.3 as per IOANRS (2006) rating soil pH with lower than 4.5 in very strongly acidic, pH ranges between 4.5 and 5.2 in strongly acidic, pH ranges between 5.3 and 5.9 in moderately acidic, pH ranges between 6 and 6.6 in slightly acidic, 6.7- 7.3 pH as neutral, 7.4- 8 pH as moderately alkaline and pH > 8.0 as strongly alkaline. Hence therefore, according to these parameters values, the soil was suitable for mung bean cultivation. Its CEC was 40 meg/kg soil (high), as per IOANRS (2006) rating CEC with > 40 meg/kg soil as very high, CEC ranges between 26 and 40 as high, CEC of 13 - 25 as medium, 6 - 12 as low, CEC < 6 as very low. Soil organic matter was 2.51% as per IOANRS (2006) rating soil organic matter (SOM) with < 1% value in very low, 1 – 2% as low, SOM of 2 – 4.2% as medium, SOM of 4.2 - 6 as high and SOM with> 6 value as very high, thus it was medium in SOM. Its total nitrogen was 0.13% as per IOANRS (2006) rating it was high in total N. Its available P content was. 9.2 ppm (low) according to IOANRS (2006) rating available P with < 3 ppm as very low, 4 -7 ppm as low, 8 -11 ppm as medium and above 12 ppm as high.

Table 1. Physicochemical properties of the experimental soil at pre-planting

Parameters	Unit	Value	Reference (Analysis method)	Rating
pH (H_2O)		7.3	H_2O with a ratio of 1.2.5	Neutral
Total N	%	0.13	Jackson, 1967	High
Organic Carbon	%	1.46	Walkley and Black, 1934	Medium
Organic Matter	%	2.51		Medium
Available Phosphorus	ppm	9.2	Olsen *et al*, ; 1954	Low
CEC	meg/kg	40	Kjeldhal procedure.	High
Texture			Sahlemedhin and Taye, 2000	Silt loam
Clay	%	12		
Silt	%	54		
Sand	%	34		

3.2. Effects on Phenological and Growth Parameters

3.2.1. Days to 50% emergence

The analysis of variance revealed that the days to 50% seedling emergence was non-significantly affected by spacing at $p<0.05$ level. In line with this AMA (2009) disclosed that crop emergence is highly affected by quality and germination percentage of mung bean seed. This might be due to the phenomenon that seed emergence was largely dependent on the utilization of reserve material and metabolites in seed tuber (Kabir *et al.,* 2004). Masarirambi *et al.* (2012) plant population density had no significant influence on days to emergence of potato. Moreover, Asmamaw, (2007) and Elfinesh *et al.* (2011) disclosed that crop emergence dates determined by the inherent characteristics of the crop.

3.2.2. Days to 50% flowering

Days to 50% flowering of mung bean was significantly affected by the main effects of intra and inter-row spacing but non-significantly influenced by their interaction effect. The longest days (44 – 46 days) of flowering were recorded from wide spacing (15 cm intra-row and 40 cm inter-row spacing) treatments while the lowest days (40-42 days) were observed on narrow spacing (5 cm intra-row and 25 cm inter-row spacing) (Table 2). Days to flowering linearly increased with plant spacing. This might be due the stiff competition among plants for available resources in narrow plant spacing that might have lead the plants to stress conditions and ultimately the plants flowered early instead of prolonged vegetative growth.

3.2.3. Days to 90% physiological maturity

Days to 90% physiological maturity showed highly significant ($p < 0.01$) response to main effects of intra and inter-row spacing but non-significantly influenced by their interaction effect. However, their interaction effect did not show significant effect on days to 90% physiological maturity. The longest days to maturity (73-77 days) were recorded on wider spacing (at 15 cm intra-row and 40 cm inter-row spacing) treatments. However, the shortest days of maturity (67-70 days) were observed at narrow spacing (5 cm intra-row and 25 cm inter-row spacing). The days to maturity linearly increased with plant spacing it might be due to plant grown on narrow spacing exposed to sever competition for various resources among the plants lead to ultimate maturity of the plant as compared to plant grown on wide spacing (Table 2).

3.2.4. Plant height

The main effects of intra and inter-row spacing had significant ($p<0.01$) effect on mung bean plant height, whereas, their interaction effect had no significant influence. The shortest plant height was observed at a planting density of 15 cm × 40 cm while the longest at 5cm x 25cm. Plant height inversely related with planting space (on intra and inter row spacing). Environmental factors and genetic characteristics of plants play an important role in determining the plant height (Rasul *et al*., 2012). Widening the intra row space by 10 cm (from 5 cm to 15 cm) decreased the plant height by 1.02 cm (32.57 cm towards 31.55 cm). Meanwhile widen the intra row spacing by 5 cm (from 25 cm to 30 cm) brought decreased the plant height 1.4 cm (33.32cm toward 31.89 cm) (Table 2). The longest plant height recorded on narrow row spacing might be due to the presence of increased competition for light as the plant population becomes denser and also probably due to lack of enough space for lateral growth then plants grew vertically resulting in to taller plants. This research finding correspond with Rasul *et al.* (2012) who reported that mung bean height was significantly decreased from 49.4 cm towards 47.7 cm by widen the inter-row spacing from 30 cm to 60 cm.

Table 2. Effects of inter row and intra row spacing on phenological stages and plant height of mung bean

	Mean separation of crop phenology and plant height		
Tretement	Days to flowering	Days to maturity	Plant height (cm)
Intra row spacing (cm)			
15	43.5^{A}	72.75^{A}	31.55^{B}
10	42.76^{B}	71.5^{B}	32.10^{AB}
	42.16^{C}	70^{C}	32.57^{A}
LSD	0.50	0.84	0.64
Interrow spacing (cm)			
40	45.85^{a}	76.67^{a}	31.52^{b}
35	43.65^{b}	73^{b}	31.57^{b}
30	41.86^{c}	70^{c}	31.89^{b}
25	39.87^{d}	66.67^{d}	33.32^{a}
LSD	0.58	0.97	0.74
CV(%)	2.07	2.07	2.07

Means followed by the same letter (s) within a column are not significantly different at 5% significant level, upper case super scripted letter = significance for intra-row spacing effect, lower case super scripted letter = significance for inter-row spacing effect, LSD= least significant difference, CV= coefficient of variation.

3.3. Yield and Yield Components

3.3.1. Pod number per plant

The number of pod per plant was highly significantly ($p < 0.001$) affected by the main effects of intra and inter-row spacing but the effect of interaction of the two parameters was insignificant. In contrast, Rasul *et al*. (2012) disclosed that inter-row spacing of mung bean has no-significant influence on number of pods. Narrow spacing (5 cm intra-row and 25 cm inter-row) gave maximum pod number while wide spacing (15 cm intra-row and 40 cm inter-row) responded minimum number of pod (Table 3). As intra-row spacing increased by 10 cm (from 5 to 15 cm), number of pods per plant decreased by 0.78 (17.05 to 16.27 pods), similarly increasing the spacing between the row by 15 cm (from 25 to 40 cm) decreases the number of pod by 3.34 (from 18.34 to 15 pods) (Table 3). The current result is in agreement with the finding of Kabir and Sarkar (2008) who reported that pod number was significantly affected by main effects of intra and inter-row spacing and the lowest number of pods were produced at 40 cm and 30 cm inter and intra-row spacing, respectively.

Table 3. Main effects of intra and inter-row spacing on number of pods per plant

Treatments	Number of pods per plant
Intra-row spacing (cm)	
5	17.05^{A}
10	16.74^{B}
15	16.27^{C}
LSD	0.41
nter-row spacing (cm)	
25	18.34^{a}
30	17.22^{b}
35	16.19^{c}
40	15.00^{d}
LSD	0.48
CV (%)	2.09

Means followed by the same letter (s) within a column are not significantly different at 5% significant level, upper case super scripted = significance for intra-row spacing effect, lower case super scripted = significance for inter-row spacing effect, LSD= least significant difference, CV= coefficient of variation.

3.3.2. Number of seeds per Pod

Number of seeds in each pod high significantly ($p < 0.01$) affected by the main and interaction effects of intra and inter-row spacing of mung bean. In line with this finding Ihsanullah *et al.* (2002) stated that intra and inter-row spacing showed significant difference on number of seeds per pod of mung bean. The number of linearly decreased with increasing planting space. Maximum number of seeds per pod obtained from plant grown on wide spacing (15 and 40 cm intra and inter row, respectively) but minimum number of seeds recorded from the plant grown on narrow spacing (5 intra row and 25 cm inter row) (Table 4). In contrast to this finding, Ihsanullah et al. (2002) revealed that the highest number of seeds per pod was recorded from narrow spacing while the lowest number of seeds per pod was recorded from wide intra and inter row spacing.

Table 4. Main effects of intra and inter-row spacing on number of seeds per pod

Treatments	Number of seeds per pod
Intra-row spacing (cm)	
5	8.84^{B}
10	10.08^{A}
15	10.07^{A}
LSD	0.21
Inter-row spacing (cm)	
25	9.68^{b}
30	9.68^{b}
35	9.26^{c}
40	10.03^{a}
LSD	0.25
CV (%)	2.06

Means followed by the same letter (s) within a column are not significantly different at 5% significant level, upper case super scripted = significance for intra-row spacing effect, lower case super scripted = significance for inter-row spacing effect, LSD= least significant difference, CV= coefficient of variation.

Similarly, the highest number of seeds per pod (11.03) was obtained from the plant grown on the interaction use of 15 cm intra-row and 40 cm inter row spacing but the lowest number of seeds per pod (9) recorded from plants grown on combined use of 5 cm intra-row and 25 cm inter row spacing (Table 5). In line with this similar finding also revealed by Kumar and Sharma (1989).

Table 5. Number of seeds per pod affected by intra and inter-row spacing of mung bean

Inter-row space (cm)	Intra-row space (cm) and mean number of seeds per pod		
	5	10	15
25	8.5i	10.03cde	10.5abc
30	8.57i	10.73ab	9.73def
35	9.53efg	9.23fgh	9ghi
40	8.77hi	10.3bcd	11.03a
LSD		0.43	
CV (%)		2.07	

Means followed by the same letter (s) are not significantly different at 5% level of significance, LSD = Least Significant Difference, CV= coefficient of variation.

3.3.3. Thousand Seeds Weight

The thousand seeds weight was highly significantly ($p < 0.01$) affected by main effects of intra-row and inter-row spacing meanwhile it was significantly ($p < 0.05$) influenced by the interaction effect. Main effects of intra and inter row spacing linearly increased the weight of thousand seeds (Table 6). This finding coherent with the study of Kabir and Sarkar (2008) who reported that plant spacing has significant influence on thousand seed weight of mung bean.

Similarly, the highest thousand seeds weight (51.1 g) was recorded on the interaction use of wide spacing (15 cm intra-row and 40 cm inter row) while the lowest (48.6 g) from plant grown on narrow spacing (combined use of 5 cm intra-row and 25 cm inter row) (Table 7). In contrast to this finding Ihsanullah *et al.* (2002) disclosed that high seed weight observed from plant grown on narrow spacing while low seed weight recorded from plant grown on wide spacing

Table 6. Main effects of intra and inter-row spacing on thousand seeds weight

Treatments	Thousand seeds weight (g)
Intra-row spacing (cm)	
5	49.31[C]
10	50.34[B]
15	50.83[A]
LSD	0.29
Inter-row spacing (cm)	
25	48.58[c]
30	50.37[b]
35	50.57[b]
40	51.13[a]
LSD	0.34
CV (%)	2.06

Means followed by the same letter (s) within a column are not significantly different at 5% significant level, upper case super scripted = significance for intra-row spacing effect, lower case super scripted = significance for inter-row spacing effect, LSD= least significant difference, CV= coefficient of variation.

Table 7. Effect of plant spacing on thousand seeds weight of mung bean

Inter-row space (cm)	Intra-row space (cm) and mean thousand seeds weight (g)		
	5	10	15
25	49[gi]	49[gi]	49[gi]
30	49.3[fg]	50.37[de]	51.43[ab]
35	49.8[ef]	50.8[cd]	51.1[bc]
40	50[e]	51.6[ab]	51.9[a]
LSD		0.58	
CV (%)		2.82	

Means followed by the same letter (s) within a column are not significantly different at 5% significant level, LSD= least significant difference, CV= coefficient of variation.

3.3.4. Grain yield

Analysis of variance showed that the main and interaction effects of intra and inter row spacing highly significantly ($p < 0.01$) affected the grain yield of mung bean. Increasing the intra row or inter row spacing resulted more grain yield but the yield declined when inter row spacing exceed 35 cm (Table 8).

Table 8. Main effects of intra and inter-row spacing on grain yield of mung bean

Treatments	Grain yield (kg/ha)
Intra-row spacing (cm)	
5	726[C]
10	1070[B]
15	1115.5[A]
LSD	26
Inter-row spacing (cm)	
25	725[c]
30	1094[a]
35	1099[a]
40	964[b]
LSD	30
CV (%)	2.06

Means followed by the same letter (s) within a column are not significantly different at 5% significant level, upper case super scripted = significance for intra-row spacing effect, lower case super scripted = significance for inter-row spacing effect, LSD= least significant difference, CV= coefficient of variation.

Similarly, the maximum grain yield of 1341.33 kg ha^{-1} was obtained from crop planted interaction use of 10 cm intra-row and 30 cm inter-row spacing but minimum grain yield of 567 kg/ha was at spacing of 5 cm intra row and 25 cm inter-row spacing. Thus, widening of intra and inter row spacing of 5 x 25 treatment by 5 cm gave more grain yield (Table 9). This result is in agreement with Ihsanullah *et al.* (2002) who reported that both intra and inter row spacing had significant effect on grain yield of mung bean. Similarly, Frizzell *et al*. (2006) also reported that grain yield of cereals increased in response to decreasing the spacing between rows.

Table 9. Effect of intra-row and inter-row spacing on grain yield of mung bean.

	Intra-row space (cm) and mean grain yield (kg/ha)		
Inter-row space (cm)	5	10	15
25	567^{k}	636.67^{j}	970.33^{f}
30	780^{h}	1341.33^{a}	1162^{cd}
35	846.67^{g}	1251.33^{b}	1198.33^{c}
40	710^{i}	1051^{e}	1131.33^{d}
LSD		52	
CV (%)		2.08	

Means followed by the same letter (s) within a column are not significantly different at 5% significant level, LSD= least significant difference, CV= coefficient of variation

3.3.5. Biomass yield

The analysis of variance indicated that the main and interaction effects of intra and inter row spacing were showed highly significant ($p < 0.001$) influence on the above ground biomass yield of mung bean. Mung bean biomass yield significantly decreased by increasing the intra or inter row spacing. Maximum biomass yield obtained due to main effect of 10 cm intra or 30 cm inter row spacing of mung bean but minimum biomass yield due to individual effect of 5 cm intra or 40 cm inter row spacing (Table 10). In this study, higher biomass yield was obtained at the narrower row spacing than wider row spacing this might be due to better resource utilization and more population in narrow rows than wider ones. This finding is in conformity with the finding of Ihsanullah *et al.* (2002) who reported that more biomass was produced at narrow row spacing than wider spacing. Similarly, Chen *et al.* (2008) reported that narrower row spacing produced higher biomass yield than wider row spacing in rice.

Table 10. Main effects of intra and inter-row spacing on biomass yield of mung bean

Treatments	Biomass yield (kg/ha)
Intra-row spacing (cm)	
5	3316^{B}
10	3583^{A}
15	3558^{A}
LSD	32
Inter-row spacing (cm)	
25	3610^{b}
30	3732^{a}
35	3487^{c}
40	3113^{d}
LSD	37
CV (%)	2.06

Means followed by the same letter (s) within a column are not significantly different at 5% significant level, upper case supers cripted = significance for intra-row spacing effect, lower case super scripted = significance for inter-row spacing effect, LSD= least significant difference, CV= coefficient of variation.

Similarly, the highest biomass yield of 3982.33 kg ha^{-1} was recorded from interaction use of 10 cm intra-row and 30 cm inter-row spacing but the lowest biomass yield of 2932 kg/ha was obtained due to interaction use of 5 cm intra-row and 40 cm inter-row spacing (Table 11). Closed inter row spacing gave higher biomass yield than wider inter-row spacing; it might be due to high density of plants and more number of branches per rows, thus average number of plants reduced in the wider rows as compared to narrow ones. This result was in line with Ihsanullah *et al.* (2002) who found that both intra and inter row spacing had significant effect on biomass yield.

Table 1. Effect of intra-row and inter-row spacing on biomass yield of mung bean

Inter-row space (cm)	Intra-row space (cm) and mean biomass yield (kg/ha)		
	5	10	15
25	3521[e]	3517.33[e]	3790.33[b]
30	3490.67[e]	3982.33[a]	3723.67[c]
35	3318.67[e]	3633.33[d]	3510.33[e]
40	2932[h]	3199.67[g]	3206.33[g]
LSD		65	
CV (%)		2.06	

Means followed by the same letter (s) within a column are not significantly different at 5% significant level, LSD= least significant difference, CV= coefficient of variation

3.3.6. Straw yield

Main effects of intra and inter row spacing were showed highly significant ($p < 0.001$) influence but their interaction effect had insignificant influence ($p < 0.05$) on straw yield of mung bean. Narrow spacing gave high straw yield but wider spacing the yield on both individual effects of intra-row and inter-row spacing (Table 12). This might be due to on narrow spacing the population density of plants is high, thus it result more straw yield. In conformity to this study, Ihsanullah *et al.* (2002) disclosed that narrow row spacing gave more straw yield. This result is in harmony with the finding of Kabir and Sarkar (2008) who reported that the highest stover yield was observed at narrow intra and inter row spacing's which may be mainly due to higher number of branches plant^{-1} and the lowest one was observed at wider intra and inter-row spacing.

Table 12. Main effects of intra and inter-row spacing on straw yield

Treatments	Straw yield (kg/ha)
Intra-row spacing (cm)	
5	2589.7[A]
10	2513.1[B]
15	2442.2[C]
LSD	13.19
Inter-row spacing (cm)	
25	2884.9[a]
30	2637.8[b]
35	2388.7[c]
40	2148.6[d]
LSD	15.24
CV (%)	2.06

Means followed by the same letter (s) within a column are not significantly different at 5% significant level, upper case super scripted = significance for intra-row spacing effect, lower case super scripted = significance for inter-row spacing effect, LSD= least significant difference, CV= coefficient of variation.

3.3.7. Harvest index

The analysis of variance showed that harvest index was high significantly ($p < 0.01$) affected by imain and interaction effects of intra and inter row spacing. Maximum harvest index (30-31%) obtained due to main effect of wide spacing 15 cm intra or 35-40 cm inter row spacing but minimum harvest index (20-22%) due to narrow spacing of 5 cm intra or 25 cm or inter row spacing (Table 13).

Similarly, the highest harvest index (35.28%) was recorded from interaction of 15 cm intra row and 40 cm inter row spacing treatment but the lowest index (15.1%) was obtained due to interaction of narrow spacing (5 cm intra-row and 25 cm inter-row) (Table 14). This result is in line with the findings of Yadav *et al.* (2014) who stated that there was maximum harvest index at narrow row spacing while minimum harvest index was recorded at wider row spacing of mung bean. Harvest index had interrelationship with grain yield and above ground biomass yield that the highest harvest index was the result of greater grain yield. Lowest harvest index was mainly due to increased biomass yield rather than grain yield which lead to decrease of harvest index.

Table 13. Main effects of intra and inter-row spacing on harvest index

Treatments	Harvest index (%)
Intra-row spacing (cm)	
5	22.04^{C}
10	29.76^{B}
15	31.55^{A}
LSD	0.51
Inter-row spacing (cm)	
25	19.93^{c}
30	29.08^{b}
35	31.36^{a}
40	30.78^{a}
LSD	15.24
CV (%)	2.06

Means followed by the same letter (s) within a column are not significantly different at 5% significant level, upper case super scripted = significance for intra-row spacing effect, lower case super scripted = significance for inter-row spacing effect, LSD= least significant difference, CV= coefficient of variation.

Table 14. Effect of intra-row and inter-row spacing on harvest index of mung bean

Inter-row space (cm)	Intra-row space (cm) and mean harvest index (%)		
	5	10	15
25	15.1^{h}	18.1^{g}	25.59^{e}
30	22.34^{e}	33.68^{bc}	31.2^{d}
35	25.5^{e}	34.44^{ab}	34.12^{abc}
40	24.21^{e}	32^{c}	35.28^{a}
LSD		1.44	
CV (%)		2.82	

Means followed by the same letter (s) within a column are not significantly different at 5% significant level, LSD= least significant difference, CV= coefficient of variation

3.4. Correlation Analysis

Plant height significantly correlated significantly and positively to pod number (r=0.65**), and straw yield (r=0.65**) but negatively to thousand seeds weight (r=-0.67**), grain yield (r=-0.57**) and harvest index (r=-0.69**). Grain yield had significant and positive correlation with plant maturity (r=0.44**), number of seeds per pod (r=0.47**), thousand seeds weight (r=-0.75**), straw yield (r=0.45**) but negatively to pod number per plant (r= -0.44**) and plant height (r=-0.57**). Similar result was reported by Canci and Toker (2014) who conclude that grain yield was significantly and positively correlated with the biological yield (r = 0.69**), pods per plant (r = 0.68**), plant height (r = 0.60**), branches per plant (r= 0.59**), straw yield (r = 58**), grains per pod (r = 0.57**), and pod number (r = 0.51**) of mung bean. This exhibited that plant height, pod number, number of seeds per pod, straw yield and harvest index had interchangeable contribution with the biomass production during the physiological process of biochemical trans location.

3.5. Economic Analysis of Mung Bean Spacing

During the economic analysis all costs were considered according local price. The cost of labor was 140 Birr a day. The labor requirement of the activity equated based on activity burden, thus during plantation and weeding narrow spacing plants, required more person days (about 20 person day/ha) while plantation and wedding of wide spacing required less manpower (about 8 person day/ha), thus the required manpower equated based on plant spacing in ranges between 8 and 20 person day/ha. Cost of harvesting and threshing was equated using 80 Birr per 100 kg grain. The cost of packing material was estimated 7 Birr per 100 kg and transportation 5 Birr per 100 kg,

According the economic analysis result the maximum net benefit (Birr 29,375.95 Birr ha^{-1}) with high marginal rate of return (MRR) was obtained from mung bean planted on 10 cm intra row and 30 cm inter-row spacing. According to CIMMYT (1988) procedure some treatments were found dominated (Table 15).

Table 2. Economic analysis result of effect of planting spacing of mung bean

Intra-row (cm)	Inter-row spacing (cm)	Average yield (kg ha^{-1})	Adjusted yield (kg ha^{-1})	Gross benefit (Birr ha^{-1})	TVC (Birr ha^{-1})	NB (Birr ha^{-1})	MRR %
	25	567	510.3	13778.1	3269.48	10508.62	0
5	30	780	702	18954	3445.84	15508.16	2834.83
	35	847	762.3	20582.1	2801.32	17780.78^{D}	-1553.35
	40	710	639	17253	2687.88	14565.12^{D}	-697.477
	25	637	573.3	15479.1	2627.44	12851.66	0
10	30	1341	1206.9	32586.3	3210.35	29375.95	2834.783
	35	1251	1125.9	30399.3	2435.83	27963.47^{D}	-7886.84
	40	1051	945.9	25539.3	2270.23	23269.07^{D}	-2916.34
	25	970	873	23571	2203.16	21367.84	0
15	30	1162	1045.8	28236.6	2362.14	25874.46	2834.783
	35	1198	1078.2	29111.4	2111.94	26999.46^{D}	-6173.93
	40	1131	1017.9	27483.3	2056.47	25426.83^{D}	-2767.02

TVC = Total variable cost; NB = Net benefit; MRR = Marginal rate of return. ^{D} = dominated

4. CONCLUSION AND RECOMMENDATION

Mungbean was lately introduced commercial crop in Ethiopia. Production of the crop is low in Ethiopia due to lack of improved varieties, disease incidence, high intensity of soil salinity, soil fertility depletion and poor cultural practices such as seed rate (spacing). However, meager information availability on spacing effect on the crop yield is hindered to improve mung bean production in the country in general and in the study area in particular. Hence therefore, response of different spacing on mung bean yield was conducted in Jile Timuga district in 2016 main season. The factorial combination of three level intra and four levels of inter row spacing treatments were laid out in randomized complete block design. The results of the finding indicated that all agronomic traits were significantly affected by different plant spacing of mung bean.

The yield and yield components parameters such as number of seeds per pod, thousand seeds weight, grain and biomass yields and harvest index were significantly affected by main and interaction effects of intra and inter row spacing. However, days to emergence non-significantly affected by main and interaction effects meanwhile days to flowering and maturity, plant height, pod number per plant and straw yield were high significantly ($p < 0.01$) influenced by main effects only. Grain and biomass yield was increased by planting mung bean on optimum space. Mean separation test indicated that combined use of 10 cm intra row and 30 cm inter row spacing treatment was responded the highest grain and biomass yield. This treatment was increased the response of grain yield by 774 kg ha^{-1} over the crop planted on narrow space (5 cm x 25 cm). The economic analysis result disclosed that interaction of 10 x 30 cm spacing treatment gave maximum net profit of 29375.95 Birr with marginal rate of return of 2834%.

Hence therefore, combined use of 10 cm intra row and 30 cm inter row spacing is found an optimum spacing to maximize the production of mung bean (N-26 variety) for Jile Timuga district. However, this conclusion has been made using the data of one season and one location and one crop variety only, thus further studies over seasons, locations and using different varieties should be tested to forward comprehensive conclusion and recommendation.

5. REFERENCES

AFINM (Addis Fortune Independent News and Media). 2016. Mung beans is the sixth common for the exchange floor for Ethiopia, newspaper, Addis Ababa, Ethiopia

AMA (Australian Mung bean Association). 2009. Mung bean Fact sheet, sow high quality planting seed.

Amhara National Regional State Bureau of Agriculture. 2015. Extension package manual of crop production in Amhara region.

Asmamaw Yeshanew. 2007. Postharvest quality of potato (*Solanum tuberosum* L.) cultivars as influenced by growing environment and storage period. M. Sc. Thesis submitted to the school of graduate studies of Haramaya University, Haramaya, Ethiopia.

Asrate Asfaw, Gurum.F., Alemayehu F. and Rezene Y. 2012. Analysis of multi-environment grain yield trials in mung bean (*Vigna radiata* L. Wilczek), Based on GGE Bipot in Southern Ethiopia, *Journal of Agricultural Science*., Tech. 14: 389-398.

Barani, M., and Daneshian J. 2012. The evaluation of physiological characters of mungbean (*Vigna radiata* L . Wilczek) under planting pattern and starter N fertilizer.

CIMMYT (Centro Internacional de Mejoramiento de Maíz y Trigo). 1988. International Maize and Wheat Improvement

Center, from Agronomic Data to farmer Recommendations: An Economics training manual.

CSA (Central Statistical Agency). 2015. 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, 2014/15 meher season), Addis Ababa, Ethiopia.

Dainavizadeh, P. amd Mehranzadeh M. 2013. Effect of seed rate on growth , yield components and yield of mung bean grown under irrigated conditions in the North of Khuzestan, 2359–2365.

Elfnesh Firdessa, Tekalign Tsegye and Solomon Woldekidan. 2011. Processing quality of improved potato (*Solanum tuberosum*) cultivars as influenced by growing environment and blanching, *African Journal of Food Science,* Vol. 5 (6), 324 - 332.

FAO. 2004. The State of Food Insecurity in the World: when people must live with fear, hunger and starvation. FAO. Rome. ISBN 92-5-104815-0.

FDREMoA (Federal Democratic Republic of Ethiopia Ministry of Agriculture). 2015. Manual for pulse crop package, Amharic version. Published through joint cooperation of ATA, EIAR. pp 91-114. Addis Ababa, Ethiopia.

Gebre Wedajo. 2015. Adaptation study of improved mung bean (*Vigna radiata* L.) varieties at Alduba , South Omo , Ethiopia, *4*(8), 339–342.

Gomez, K. and Gomez, A. 1984. *Statistical Procedure for Agricultural Research, Second Edition*. A Wiley Inter-Science Publication, New York, USA.

Ihsanullah, Taj, F. H., Akbar, H., Basir, A., and Ullah, N. 2002. Effect of row spacing on agronomic traits and yield of mung bean (*Vigna radiata* L.Wilczek). *Asian Journal of Plant Sciences,* Volume 1, number 4, 328-329

Imrie, B. 1998. The New Rural Industries: A Hand Book for Farmers and Investors: Mung Bean. http://www.rirdc.gov.au/pub/handbook/mungbean.html. Accessed on May 15, 2016.

IOANRS (Investment Office of Amhara National Regional State).2006. Potential Survey, Identification of Opportunities and Preparations of Projects Profiles and Feasibility Studies. Part one potential assessment, unpublished soil survey study report by Development Studies Association (DSA) and Shawel Consult International (SCI).

Jackson, M.L. 1967. Soil Chemical Analysis .Prentice-Hall of India, New Delhi.

JTDAO (Jila Timuga District's Agricultural Office). 2016. Annual agriculture progressive report of Jila Timuga District in 2015/16 season, unpublished report.

Kabir, M..H., Alam, M..K.,Hossain, M..A., Hossain, M.M., and Hossain M..J. 2004. Yield performance of whole-tuber and cut-piece planting of potato. *Tropical Science*, 44:.16-19.

Kassahun Bekele. 2013. An overview of Ethiopian pulses production and market perspective". ACOS Ethiopia PLC.

Kidane Georgis. 2010. Environment and natural resources management working paper. agricultural based livelihood systems in dry lands in the context of climate change inventory of adaptation practices and technologies of Ethiopia, Addis Ababa, Ethiopia.

Kumar, A. and Sharma B. 1989. Effects of row spacing and seed rate on root growth, nodulation and yield of black gram. Indian Journal Agriculture Science. 59, 728-729

Masarirambi, M.T., Mandisodza F., Mashingaidze A., and Bhebhe E. 2012. Influence of plant population and seed tuber size on growth and yield components of potato (*Solanum tuberosum*). *International Journal of. Agricultural Biology*. 14: 545-549.

Mehari Muez and Tesfay M.izan. 2015. Evaluation of mung bean genotypes for seed yield and other yield related traits in low lands of South Tigray , Ethiopia, *5*(13), 165–168.

Mirzaei, A., Naseri R., Vafa P. and Moradi M. 2014. Effects of drought stress on qualitative and quantitative traits of mung bean, 8(2), 148–152.

Mogotsi, K. 2006. Mung bean (*Vigna radiata* (L.) R. Wilczek. In: Brink, M. and Belay, G. (Editors). PROTA 1: Cereals and pulses/Cereals legumes, CD-Rom. PROTA, Wageningen, Netherlands. Pp 23-29

Nawale E. 2011. Effect of planting date and population density on grain yield of two varieties of Mung bean (*Vigna radiata* (L.) Wilckzek.), MSc Thesis, University of Lusaka , Lusaka, Zambia.

Olsen, S.R. Cole, C.V. Watanabe, F.S. and Dean, L.A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDA Circular 939: 1-19.

Oplinger, E., L. Hardman, A. Kaminski, S. Combs and. Doll. J. 2016. Alternate field crop manual. Corn Agronomy.

Parviz, D. and Mohammad M. 2015. Effect of seed rate on growth, yield components And yield of mung bean grown under irrigated conditions in the North of Khuzestan. *International Journal of Agriculture and Crop Sciences*.

Rasul, F., M A. Cheema, A. Sattar, M. F. Saleem and Wahid M.A. 2012. Evaluating the performance of three mung bean varieties grown under varying inter-row spacing. *The Journal of Animal & Plant Sciences*, 22(4): 2012, pp 1030-1035. ISSN: 1018-7081

Roslim, D. 2015.. Agronomic characters and heritability of the third generation of Kampar strain green beans (*Vigna radiata* L.). *Nusantara Bioscience*, *7*(2), 160–164. http://doi.org/10.13057/nusbiosci/n070218.

Sahlemedhin Serstu and Taye Bekele. 2000. Procedure for soil and plant analysis .National Soil Research Centre, Ethiopian Agricultural Research Organization, Addis Ababa, Ethiopia.

SAS Institute Inc. 2002. *SAS User's Guide, Statistics* v. 9.1 (ed.), SAS Inst. Cary, NC, USA.

Tesfa Binalfew. 2012. Influence of plant spacing on seed tuber production of potato (*Solanum tuberosum* L.) cultivars grown in eastern Ethiopia. MSc. Thesis submitted to School of Plant Sciences, Haramaya University, Haramaya, Ethiopia.

Walkley, A. and Black C.A. 1934. An examination of different methods for determining organic carbon content.

Winch T. 2006. Growing Food, Guideline to food production. Springer, Dordrecht, The Netherlands.

World Bank. 2006. Country Brief. Development Progress.