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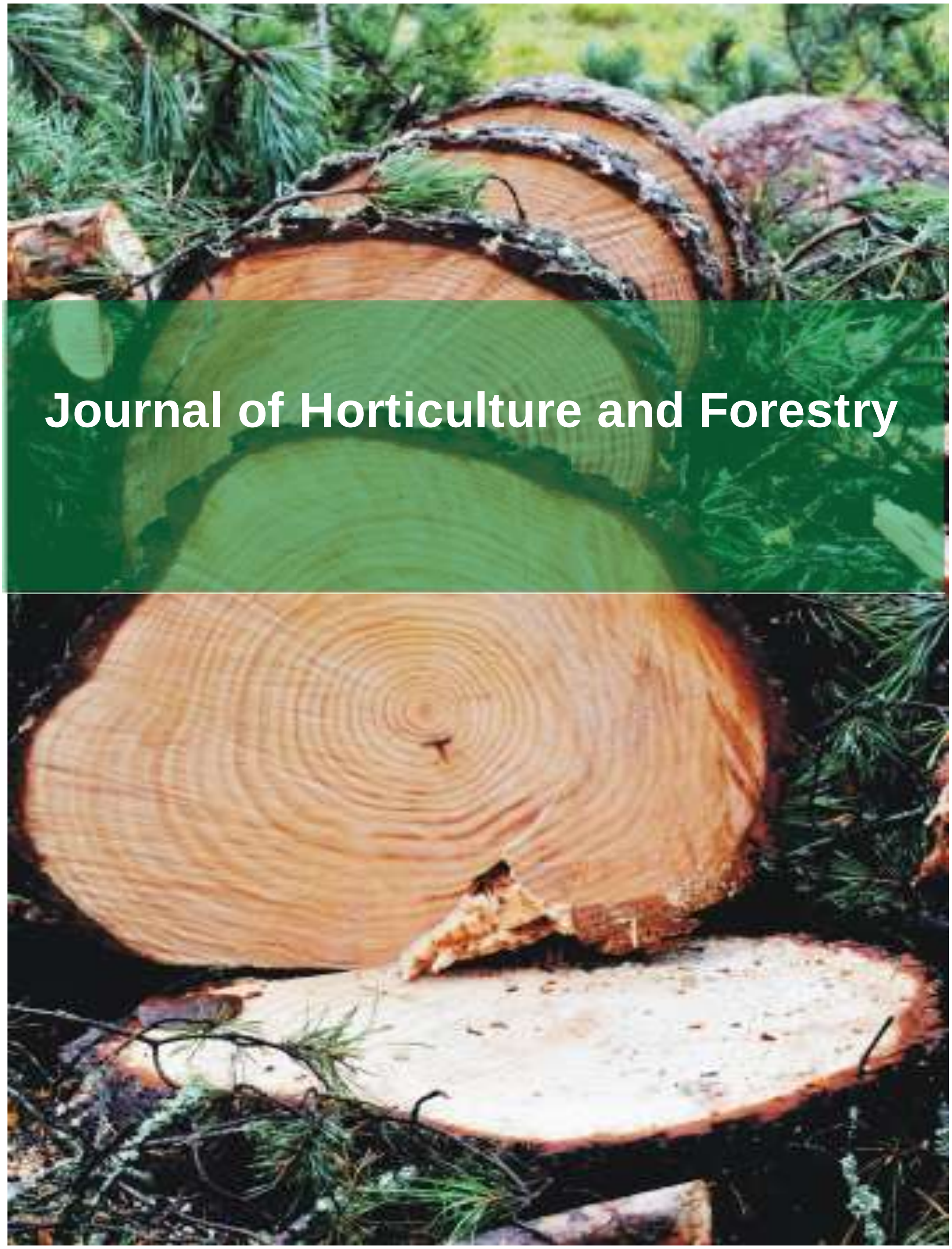

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Full Length Research Paper

Collection and characterization of garlic (*Allium sativm* L.) germplasm for growth and bulb yield at Debre Markos, Ethiopia

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Garlic (*Allium sativm* L.) is the most widely used crop among cultivated *Allium* species in Ethiopia and it has a wide range of climatic and soil adaptation. Production of the crop is confronted with a number of problems and the total production and productivity in the country is low. Among many contributing factors, lack of improved varieties and garlic rust are the major ones. In view of this, an experiment was carried out to screen garlic germplasm for yield and diseases tolerance at Debre Markos University College of Agriculture and Natural Resource research field during 2013/14-2016/2017. The experiment was arranged in randomized complete block design with three replications. The result of the study showed high heritability together with high and medium genetic advance for days to physiological maturity, bulb weight, clove number, clove weight and total bulb yield between germplasms and significant variation among the germplasms tested with regard to plant height (cm), leaf length, (cm), maturity date, leaf number, bulb weight (g), clove number, clove weight (g), bulb diameter (cm) and total bulb yield (kg/ha). Different germplasms resulted in better performance with respect to recorded parameters. Germplasms 5 and 18 were found to be superior followed by germplasms 13 and 38. In addition, they recorded maximum plant height, leaf length, bulb weight, clove weight, bulb diameter, total yield, shorter maturity date and moderately susceptibility to rust. The result generally indicated that germplasms G5 (7640 kg), G18 (6929 kg), G38 (4626 kg) and G13 (4601 kg) are promising germplasm in the study area. It will be good to repeat the experiment at multi locations for National Variety Trail test.

Key words: Garlic, germplasm, growth, yield.

INTRODUCTION

Garlic (*Allium sativum* L.) is the second most widely cultivated *Allium* next to onion (Brewster, 1994). Garlic is primarily grown for its cloves used mostly as a food-flavouring condiment. Green tops are eaten fresh or

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cooked. In tropical areas, consumption of immature bulbs for salad is also popular (Rubatzky and Yamaguchi, 1997; Fritsch and Friesen, 2002). Garlic is one of the best-studied medicinal plants that have antibacterial and antiseptic properties (Keusgen, 2002).

Allium crops are planted in many parts of Ethiopia, including East and West Gojam Zones of the Amhara Regional State and it has been used long ago as vegetable and spice for flavoring a variety of Ethiopian local dishes (Alemu, 1998). Besides, it is used as traditional medicine for relief from any painful condition occurring inside the body. Today, the importance of garlic is well known all over the world, especially in pharmaceutical industries as well as botanicals against some plant diseases and insect pests (Brewster, 1994). Regarding its economic importance to a grower, as high value crop, it is sold for higher price when compared with other *Allium* vegetables such as onion, shallot and leek. *Allium* groups are important bulb crops in Ethiopia and produced by small and commercial growers for local use and export to Europe, the Middle East and USA, to earn foreign currency (Metasebia and Shimelis, 1998). These crops are also produced for home consumption and as a source of income to many peasant farmers in many parts of the country (Getachew and Asfaw, 2000). Metasebia and Shimelis (1998) reported that the per capita consumption of these crops is estimated to be over 1.74 and 5.9 kg in the rural and urban center, respectively.

In Ethiopia, the total area under garlic production in 2015/16 reached 11,845.53 ha and the production is estimated to be 107,743.5 tonnes (FAOSTAT, 2015/2016). The production is spread throughout the country both under irrigation and rain fed conditions in different agro climatic regions (CACC, 2002). It has a wide range of climatic and soil adaptation (Lemma and Herath, 1994).

In Ethiopia, garlic is produced mainly in the mid and high altitudes of the country (Getachew and Asfaw, 2000; CACC, 2002). It had also been under commercial production by Horticultural Development Corporation at Debre Zeit, Guder and Tseday State Farmers (Getachew and Asfaw, 2000). Being a cash crop in many parts of the country, increasing its productivity per unit area and production will enable farmers to get encouraging returns and contribute its role in achieving food security (DZARC, 2006). However, major production constraints of garlic include lack of improved varieties, garlic rust, downy mildew, basal rot, white rot, purple blotch and onion thrips (Getachew and Asfaw, 2000). Because of its diverse economic and dietary importance, improving its yield need to be given top priority in breeding study.

Hence, considering garlic as one of the potential vegetable crop for consumption as well as for the market, it is imperative to increase its productivity together with desirable attributes through genetic manipulation. In many countries, garlic is a long established crop and cultivars that are well adapted to local conditions and the local market have been selected (Rabinowitch and Currah, 2002). Great efforts have been made in the selection and breeding of locally adapted cultivars and the development of cultural techniques because many traits of garlic including bulb size, shape, maturity date, the percentage of thick-necked and double bulbs are influenced by the environment (Rabinowitch and Brewster, 1990). For the development of suitable varieties of garlic, it is essential to evaluate the characters of the available germplasm properly for selection (Alam et al., 2010).

Garlic germplasm is diverse in Ethiopia and in recent years, collection has been carried out by the Ethiopian Institute of Agricultural Research (EIAR) at Debre Zeit Agricultural Research Center and screening trials were conducted on-station at Debrezeit. However, this screening was locality specific and materials were tested only under Central and South central garlic growing areas to evaluate their performance and may not perform well beyond these locations. Therefore, it is necessary to conduct regional based germplasm screening for further breeding work and to screen varieties for disease reaction. This study was therefore, conducted to collect and screen potential garlic germplasm for growth, yield, disease tolerance and further varietal improvement and also to estimate the nature and magnitude of variability for yield and yield related characters.

MATERIALS AND METHODS

Description of the study area

The experiment was conducted at Debre Markos University College of Agriculture and Natural Resource research field during 2013/14-2016/2017. Debre Markos University is geographically located at about 10° 21’ latitude North and 37°43’ longitude East; its elevation was estimated to be 2509 m above sea level. The annual average temperature was 18.5°C, while the maximum and minimum recorded temperatures were 24 and 4°C, respectively. Annual average rainfall was 1380 mm. the general climatic condition of Debre Markos is humid, characterized by sub-tropical weather condition (Planning and Economic Development of East Gojjam, 2004 cited by Yeshiwas, 2017).

Experimental materials and design (collected germplasm)

Fifty garlic germplasms were collected from 14 Districts of East Gojjam, West Gojam and Awi zone and used as planting materials. The 50 garlic germplasms collected were considered as the treatments for the experiment. In the first phase, 50 collected garlic germplasms were planted in a non-replicated trial in blocks. Germplasms were strictly tagged in blocks. 34 best performing lines were selected based on vegetative, disease, yield and yield component parameters. In the second phase, the already screened materials were evaluated by using simple lattice design to start variety preliminary yield trial. The materials were evaluated using standard check obtained from Debrezeit Agricultural Research Center. During the third phase, best performing 14 lines were selected based on vegetative, disease, yield and yield component parameters and pre-regional variety trial were started at on-station (Debre Markos), using randomized complete block design in three replications.

Experimental procedures

Fifty germplasms of garlic were collected and stored for planting. At planting time, cloves were separated from the bulbs, sorted and graded according to their size category: large (2.0 to 2.5 g), medium (1.5 to 1.9 g) and small (1.0 to 1.49 g) (Fikreyohannes, 2005). Land preparation was started in April. The experimental plots were planted at the beginning of June, 2013/2014 to 2016/2017 at the depth of 3 cm by sticking the clove into the raised bed by hand. The cloves were spaced 10 cm between plants and 30 cm between rows. The space between block and between plots was 1 and 0.5 m, respectively. There were four rows per plot and 10 plants per row with a total of 40 plants per plot. Fertilizers were applied according to the national recommendation at the rate of 200 kg di ammonium phosphate at planting and 150 kg urea: 75 kg of urea at time of planting and the other 75 kg at after two months of planting (EARO, 2004). Hand weeding was done every 15 days interval.

Data collected

Data were recorded on the middle twelve plants and the plot averages were used for analysis by adapting IPGRI (2001). Data were collected for plant height (cm), leaf length (cm): leaf number per plant, days to physiological maturity, average bulb weight (g), bulb diameter, bulb color, shape of dry bulb, number of cloves per bulb, clove weight (g), total yield (kg/ha) and rust severity.

Rust severity

Garlic rust severity was assessed from 10 plants which were randomly pre-tagged with red ropes in the middle two rows of each plot (five plants per row). Assessment started 70 days after planting. The final date of disease assessment (98 days after planting) was used for analysis. Disease severity was estimated in percentage of leaf surface covered with lesions. Disease severity was rated using standard disease scales of 1-5 for rust severity, where, 1 = 1 - 10%, 2 = 11 - 25%, 3 = 26 - 50%, 4 = 51 - 75%, and 5 = 76 - 100% of the leaf surface covered with lesion (Koike et al., 2001) and average severity of the 10 plants per plot was used for statistical analysis. The scores were changed into percentage severity index (PSI) for analysis using the formula of Wheeler (1969).

$$PSI = \frac{Snr}{NprxMsc} x100 \quad (1)$$

Where, Snr = the sum of numerical ratings, Npr = the number of plant rated, Msc = the maximum score of the scale. Mean disease severity from each plot was used in data analysis.

Data analysis

The data obtained were subjected to analysis of variance (ANOVA) by using SAS software version 9.2 (SAS, 2008). The ANOVA model used for the analysis was

$$Y_{ij} = \mu + T_\iota + \beta_\varphi + \varepsilon_{\iota\varphi} \quad (2)$$

Where, Yij is any observation for which *i* is the treatment factor, *j* is the blocking factor, μ is overall mean, *T*i is is the effect for being in treatment *I, B*j is the effect for being in block *j,* $\varepsilon_{\iota\varphi}$ = error term due to the uncontrolled factors.

When ANOVA showed significant differences, mean separation was carried out using least significant difference (LSD) test at 5% significance level (Gomez and Gomez, 1984). Genetic parameters including genotypic and phenotypic variance, genotypic and phenotypic coefficient of variance, heritability (broad sense) and the expected genetic advance (GA), were calculated using the formula given by Falconer (1981), Jim et al. (2003) and Johnson et al. (1955).

RESULTS AND DISCUSSION

Plant height

The analysis of variance indicated that there were significant (p<0.0001) differences between germplasm (Table 1). Accordingly, the tallest plant height of 72.83 cm was recorded from germplasm G5 collected from Dembecha- Senseb Gebriel area which was at par with germplasms G13 and G11 collected from Dejen – Gibgib (66.78) and Dejen – Jeva (66.22), respectively. The shortest plant height was attained from germplasm G24 collected from Sekela - Yedem Mariyam (43.44 cm) (Table 1). The difference of germplasms for plant height was due to genetic difference. This finding was in line with the findings of Alam et al. (2010) who reported significant variation for plant height due to the difference between genotypes. Islam et al. (2004) also reported significant variation for plant height due to varietal difference.

Days to physiological maturity

Germplasm showed very highly significant *(p*<0.0001*)* variations with respect of days to maturity (Table 1.). The shortest period of maturity was shown by germplasms G5 (108 days) and G18 collected from Awebel - Yazera giorgis (109.33 days), G13 collected from Dejen – Gibgib (109.33 days), G5 obtained from Dembecha- Senseb Gebriel (109 days), G38 collected from Banja – Satma (108.66 days) and G11 collected from Dejen – Jeva (108 days). Germplasm G48 from Sekela - Yedem Mariyam, G50 obtained from Sekela-Menbeta took the maximum (136 and 131.33) days respectively, to bulb maturity (Table 1).

Leaf length

There were very highly significant differences (p<0.001) between germplasm for leaf length (Table 1). The longest (46.11 cm) leaf length was recorded from germplasm G5 obtained from Dembecha- Senseb Gebriel, which was to par with values recorded by germplasm G11 collected from Dejen – Jeva (41.44 cm) and G13 from Dejen – Gibgib (42.72 cm). While the shortest (32.16 and 31.22 cm) leaf length was obtained from germplasm G15 (Dejen- Borbor) and G48 (Sekela - Yedem Mariyam), respectively (Table 1). The longest leaf length was

Table 1. Plant height, maturity date, leaf length, and leaf number of bulbs of 16 selected garlic germplasms.

Germplasms code	Collection area	Plant height (cm)	Maturity date	Leaf length (cm)	Leaf number
G-45	Sekela – Lijima	62.22^{bcdef}	128.33^{abc}	37.72^{bcde}	9.33^{bcde}
G-14	Dejen – Koncher	53.94^{efg}	119.66^{dc}	32^{fg}	9^{cde}
G-17	Awebel –Dehguma	57.11^{cdefg}	113d^{e}	34.11^{cdefg}	9.33^{bcde}
G-15	Dejen- Borbor	49.39^{gh}	121.33^{dc}	32. 16 ^{efg}	9.22^{bcde}
G-10	Bure – Kebsa	55.89^{defg}	127.33^{abc}	37.44^{bcdef}	8^{ef}
G-24	Sinan - Debre Zeit	62.33^{bcde}	124^{bc}	41.44^{ab}	9.44^{bcd}
G-48	Sekela - Yedem Mariyam	43.44^{h}	136^{a}	31.22^{g}	7^{f}
G-38	Banja – Satma	65.11^{abcd}	108.66^{e}	42.11^{ab}	9.89^{abc}
G-16	Awebel – Abkejit	57.00^{cdefg}	125.33^{bc}	38.22^{bcd}	9.11^{bcde}
G-50	Sekela-Menbeta	58.61^{cdefg}	131.33^{ab}	41.32^{ab}	9.55^{bcd}
G-18	Awebel - Yazera giorgis	65.28^{abc}	109.33^{e}	39.61^{bc}	9.11^{bcde}
G-13	Dejen – Gibgib	66.78^{ab}	109.33^{e}	42.72^{ab}	10.44^{ab}
G-11	Dejen – Jeva	66.22^{abc}	109^{e}	41.44^{ab}	10.22^{abc}
G-5	Dembecha- Senseb Gebriel	72.83^{a}	108^{e}	46.11^{a}	8.33^{def}
Kuriftu	Standard Cheak	52.89^{fg}	128^{abc}	33.94^{defg}	9.77^{abc}
Bishoftu	Standard Cheak	54.67^{efg}	129.^{abc}	34.94^{cgdef}	11^{a}
LSD (5%)		9.38	9.34	5.65	1.39
CV (%)		9.539	4.65	8.95	9.02

Means followed by the same letter(s) within a column are not significantly different at 5% level of significance

obtained from germplasms having the largest clove weight. This is because large-sized cloves have higher food reserves which might have enabled the plants to produce larger leaves as compared to small-sized cloves with relatively smaller reserve food. This result is in agreement with the findings of Ahmed et al. (2007) and Danna et al. (2000) who reported that availability of more food reserves in cloves allowed young garlic plants to be more vigorous in their growth and development.

Number of leaf per plant

There were highly significant (p<0.01) differences in number of leaves per plant (Table 1). The highest number of leaves (11) was obtained from variety *bishoftu* (standard cheak) which was at par with germplasm G13 (Dejen – Gibgib, 10.44), G11 *Dejen – Jeva, 10.22) and G38 (Banja – Satma, 9.89). The lowest number of leaves (7 and 8) was recorded from germplasms G48 (Sekela - Yedem Mariyam) and G10 (Bure – Kebsa), respectively (Table 1).

Bulb weight

Highly significant *(p<0.01)* difference was observed between collected germplasm for the bulb weight (Table 2). The result indicates that germplasm G18 Awebel - Yazera giorgis had the highest weight of bulb (21.24 g). However, it was not significantly different from G13 (Dejen – Gibgib, 17.51) and G5 (Dembecha- Senseb Gebriel, 19.90). The lowest weight of bulb (6.63 and 5.34 g) was recorded from germplasm G14 (Dejen – Koncher) and G48 (Sekela-Yedem Mariyam), respectively (Table 2).

The present finding is in agreement with the results of Islam et al. (2007) who reported significant variation for bulb weight due to genotypic difference. They also reported that higher bulb weight in garlic is correlated with higher leaf length of plants. Similar trend was also found in the present study.

Number of cloves per bulb

The statistical analysis indicated that varieties have very highly significant (p<0.001) difference on clove number (Table 2 and Appendix Table 1). The maximum number of cloves per plant was obtained from G 50 (Sekela-Menbeta; 21.06) and G 48 (Sekela - Yedem Mariyam; 20.40), which was not significantly different from G10 (18.5) Bure – Kebsa, Kuriftu (17.53). The lowest number of cloves (10.40, 11.03 and 11.06) was recorded from germplasm G14, G17 and G15, respectively.

Generally, the lowest number of cloves per bulb was recorded from medium sized cloves. Similar observations were made by Fikeryohhanis (2005) who reported that clove size had significant effects on the number of cloves per bulb.

Table 2. Bulb weight (g), clove number, clove weight (g), bulb diameter (cm) and total yield (q/ha) of bulbs of 16 selected garlic germplasms.

Germplasms code	Collection area	Bulb weight (g)	Clove number	Clove weight (g)	Bulb diameter (cm)	Total yield (kg/ha)
G-45	Sekela – Lijima	14.33[abcde]	13.8[defg]	1.03[bc]	3.6[a]	4134[dc]
G-14	Dejen - Koncher	6.63[f]	10.40[g]	0.63[def]	2.28[cd]	2425 [dce]
G-17	Awebel -Dehguma	11.32[cdef]	11.03[fg]	1.07[bc]	3.22[ab]	4097[dc]
G-15	Dejen- Borbor	7.57[ef]	11.06[fg]	0.69[cde]	2.46[bc]d	2685[cde]
G-10	Bure – Kebsa	7.36[ef]	17.53[abc]	0.42[ef]	2.54[bcd]	2082[de]
G-24	Sinan - Debre Zeit	10.11[def]	14.51[cdef]	0.71[cde]	2.71[bcd]	2776 [cde]
G-48	Sekela - Yedem Mariyam	5.34[f]	20.40[a]	0.26[f]	2.1 [d]	1349[e]
G-38	Banja – Satma	14.71[abcd]	14.91[bcde]	0.97[bc]d	3.15[ab]	4626[bc]
G-16	Awebel - Abkejit	11.02[cdef]	11.66[efg]	0.96[bcd]	2.77[bcd]	3090[cde]
G-50	Sekela-Menbeta	10.01[def]	21.06[a]	0.46[ef]	2.76[bcd]	2288[cde]
G-18	Awebel - Yazera giorgis	21.24[a]	14.20[cdef]	1.5[a]	3.8[a]	6929[ab]
G-13	Dejen – Gibgib	17.51[abc]	16.13	1.06[bc]	3.12[ab]	4601[bc]
G-11	Dejen – Jeva	14.02[bcde]	14.4[cdef]	0.98[bcd]	3.07[abc]	4420[dc]
G-5	Dembecha- Senseb Gebriel	19.90[ab]	14.33[cdef]	1.32[ab]	3.28[ab]	7640[a]
Kuriftu	Standard Cheak	4.87[f]	18.5[ab]	0.26[ef]	2.16[d]	1399[e]
Bishoftu	Standard Cheak	6.51[f]	11.89[efg]	0.52[ef]	2.22[d]	1695[e]
LSD(5%)		7.11	3.64	0.39	0.83	23.79
CV (%)		37.42	14.83	29.66	17.62	40.59

Means followed by the same letter(s) within a column are not significantly different at 5% level of significance.

Clove weight

Very highly significant (p<0.001) difference was observed between germplasm for average clove weight (Table 2). The largest average clove weight was recorded from germplasm G18 (1.5 g). However, it was not significantly different from G 5 (1.32). The lowest average clove weight (0.26 g) was recorded for G 48.

Bulb diameter

The ANOVA result for the mean bulb diameter of germplasm showed highly significant (p<0.01) difference (Table 2 and Appendix Table 1). The result indicated that the germplasm G18 and G45 gave the highest (3.8 and 3.6 cm) diameter of bulb, respectively. The lowest diameter of bulb (2.1, 2.16 and 2.22 cm) was obtained from germplasm G48, standand checks Kuriftu and Bishoftu, respectively.

Total bulb yield

Different germplasm showed very highly significant *(p<0.001)* variations on yield of garlic per hectar (Table 2). Germplasm G5 gave the highest yield (7640 kg) per hectar. But it was statistically similar with germplasm G18 (6929 kg) yield per hectar followed by germplasm G38 (4626 kg) and G13 (4601 kg) yield per hectar. The lowest yield per hectar (1471 kg/ha) was obtained from germplasm G48 (1349 kg/ha), Kuriftu (1399 kg/ha) and Bishoftu (1695 kg/ha) (Table 2). This is because total bulb yield in garlic is significantly correlated with leaf length (r=0.89***), leaf number (r=0.39*), bulb weight (r=0.71***) and clove weight (r=0.64***). The present finding is in agreement with the results of Fikeryohhanis (2005) who reported significant variation for bulb yield due to germplasm difference.

Rust severity

The statistical analysis indicated that varieties have no significant (p>0.05) difference on rust severity (Table 3). None of the germplams showed high resistance to rust. The higher disease severity of rust in garlic might be attributed to the availability of favorable temperature and high rain/moisture for disease development during the growing season of the crop. Dixon (1981) reported that rust flourished vigorously at 15°C and 95% relative humidity.

Table 3. Rust severity, shape of bulbs and bulb skin color of bulbs of 16 selected garlic germplasms.

Germplasms code	Collection area	Rust severity (%)	Shape of dry bulb	Bulb skin color
G-45	Sekela – Lijima	84.444	Ciruclar	Creamy
G-14	Dejen – Koncher	80	Ciruclar	Light violet
G-17	Awebel –Dehguma	86.667	Broadly ovate	White
G-15	Dejen- Borbor	84.444	Ciruclar	White
G-10	Bure – Kebsa	83.889	Ciruclar	Violate
G-24	Sinan - Debre Zeit	88.88	Ciruclar	Light violet
G-48	Sekela - Yedem Mariyam	81.667	Ciruclar	Violet
G-38	Banja – Satma	88.333	Heart shaped	White strip
G-16	Awebel – Abkejit	78.889	Broadly ovate	Light violet
G-50	Sekela-Menbeta	76.111	Ciruclar	Violet
G-18	Awebel - Yazera giorgis	89.44	Broadly ovate	White
G-13	Dejen – Gibgib	89.44	Broadly ovate	Creamy
G-11	Dejen – Jeva	86.333	Broadly ovate	Light violet
G-5	Dembecha- Senseb Gebriel	85	Ciruclar	Light violet
Kuriftu	Standard Cheak	78.889	Ciruclar	Creamy
Bishoftu	Standard Cheak	88.889	Ciruclar	White
LSD (5%)		13.41		
CV (%)		9.52		

Means followed by the same letter(s) within a column are not significantly different at 5% level of significance.

Genotypic and phenotypic variances

Genetic variability alone is a prerequisite for response to selection; and knowledge of the extent and nature of phenotypic variability is, then, one of the basic needs for the breeders to manage the crop successfully (Adam, 2006). The amount of genotypic and phenotypic variability that exists in a species is essential in developing better varieties and in initiating a breeding program. Estimated components of genotypic, phenotypic and environmental variances studied are presented in Table 4.

Plant height (45.156 cm), days taken for physiological maturity (80.556), bulb weight (20.183 g), leaf length (16.133) and total bulb yield (27393kg) had larger genotypic variance. Therefore, the larger proportion of phenotypic variance observed on these traits was attributed to the genotypic variance than the environment variance and hence, can be exploited in breeding program. For those traits which had large genetic variance relative to the environmental, accessions may be evaluated adequately by testing few replicates, location and years (Miller et al., 1957).

Leaf number (0.683), clove weight (0.1143 g) and bulb diameter (0.1866 cm) had low genotypic variability when compared with their environmental variability. Miller et al. (1957) also suggested that traits with high environmental variances should be tested in sufficient number of replications, years and location. The partitioning of the total phenotypic variance into its components allows understanding the role of heredity and environment (Mayer and Deshmukh, 2003).

Phenotypic and genotypic coefficient of variability

The results revealed a wide range of variability among 14 garlic genotypes for quantitative traits (Table 4). The phenotypic variance (σ2P) of all traits was higher than the genotypic variance (σ2G); similarly, the phenotypic coefficient of variation (PCV) was also higher than genotypic coefficient of variation (GCV). The highest PCV was recorded for the traits bulb weight (54.33%), clove weight (51.37%) and total bulb yield which were 62.173%. In contrast, the lowest PCV belonged to the characters: days to physiological maturity (8.78%). The GCV ranged from 7.45 (days to physiological maturity) to 47.08% (total bulb yield). The next highest GCV contained the characters clove weight (41.96%). Coefficients of variation studies indicated that the estimates of PCV were slightly higher than the corresponding GCV estimates for all the traits studied, indicating that the characters were less influenced by the environment. Therefore, selection on the basis of phenotype alone can be effective for the improvement of these traits.

Heritability

Heritability is a good index of characters transmission from parents to its progeny. The estimates of heritability

Table 4. Estimation of parameters of variability (genotypic variances, phenotypic variances, environmental variances, genotypic coefficient of variation (GCV %), phenotypic coefficient of variation (PCV %), heritability in broad sense (H %), and genetic advance as percent of mean (GAM) in garlic germlasms for different traits.

Character	Mean	$\partial^2\gamma$	$\partial^2\varepsilon$	$\partial^2\pi$	GCV%	PCV%	H%	GA	GAM
PH	58.98313	45.156	31,65	76.806	11.39	14.85	58.79	10.59	17.95
DM	120.47	80.556	31.39	111.946	7.45	8.78	71.959	15.65	12.99
LL	37.90958	16.133	11.51	27.643	10.59	13.86	58.36	6.308	16.64
LN	9.298750	0.683	0.70	1.383	8.88	12.65	49.38	1.1939	12.84
BW	11.40646	20.183	18.22	38.403	39.38	54.33	52.556	6.697	58.714
CN	14.74375	9.141	4.78	13.921	20.51	25.30	65.66	5.036	34.158
CW	0.805625	0.1143	0.057	0.1713	41.967	51.37	66.72	0.5677	70.38
BD	2.831458	0.1866	0.24	0.4266	15.25	23.06	43.74	0.587	20.73
TY	35.14833	273.93	203.61	477.54	47.089	62.173	57.36	25.77	73.32

PH = Plant height, DM= days to maturity, LL= leaf length, LN= leaf number, BW= bulb weight , CN= clove number, CW= clove weight, BD= bulb diameter, TY= total bulb yield.

Table 5. Simple correlation on growth, yield and rust of garlic germplasms.

Parameter	PH	MD	LL	LN	BW	CN	CW	BD	TY	RS
PH	1	-0.58***	0.89***	0.39*	0.71***	0.02ns	0.64***	0.64***	0.69***	0.21ns
MD		1	-0.41*	-0.22***	0.56***	0.34**	-0.64***	-0.43**	0.61***	-0.41*
LL			1	0.3 *	0.66***	0.24ns	-0.52**	-0.53***	0.6***	0.11ns
LN				1	0.20ns	-0.16ns	0.2Ns	0.17ns	0.14ns	0.12ns
BW					1	0.05ns	0.91***	0.78***	0.92***	0.25ns
CN						1	-0.30*	0.01ns	-0.06ns	-0.12Ns
CW							1	0.74***	0.89***	0.29*
BD								1	0.76***	0.21ns
TY									1	-0.27ns
RS										1

help the plant breeder in the selection of elite genotypes from diverse genetic population. Heritability is classified as low (below 30%), medium (30-60%) and high (above 60%). The characters studied in the present investigation expressed medium to high heritability estimates ranging from 43.74 to 71.959%. Among the yield characters, broad sense highest heritability was recorded by, days to maturity (71.959), clove number (65.66), clove weight (66.72g) and total bulb yield (57.36) whereas, leaf length (58.36 cm) and plant height (58.79 cm) recorded medium heritability value. High heritability values indicated that the characters under study were less influenced by environment in their expression. The plant breeder, therefore, may make his selection safely on the basis of phenotypic expression of these characters in the individual plant by adopting simple selection methods. High heritability indicates the scope of genetic improvement of these characters through selection.

Estimate of genetic advance

The genetic advance is a useful indicator of the progress that can be expected as a result of selecting the pertinent population. Heritability in conjunction with genetic advance would give a more reliable index of selection value (Johnson et al., 1955). Genetic advance was highly expressed as percentage of mean for characters (>20%), for bulb weight (58.714), clove number (34.158) clove weight (70.38) bulb diameter (20.73) and total bulb yield (73.32). Genetic advance was moderate (10-20%) for plant height (17.95), days to physiological maturity (12.99), leaf length (16.64) and leaf number (12.84). No low genetic advance (<20%) was observed.

Correlation

The present study showed the existence of significant and positive associations between yield and yield related parameters (Table 5). Plant height was positively and significantly correlated with leaf length, leaf number, bulb weight, clove weight, total yield per hectare and non-Plant height was non-significantly correlated with plant height. Maturity date was negatively and significantly correlated with leaf length, leaf number per plant and clove weight. Leaf length was significantly and positively correlated with bulb weight and total yield. Bulb weight was significant and positively correlated with clove number and total yield. Clove number was negatively correlated with clove weight and total bulb yield. Positive correlation was observed between clove weight and total yield. There was a weak correlation between rust severity and, , leaf number and bulb weight. Rust severity was negatively correlated with clove number, maturity date and total bulb yield per hectare.

Conclusion

The results of the present study indicated that germplasms G5, G18, G13 and G38 gave the highest results in all the mentioned parameters due to genotypic difference. This might be due to the fact that germplasm had a good genetic potential which enhanced more cell division and cell elongation, resulting in best performance of germplasms G5, G18, G13 and G38, with outstanding performance for growth and yield characteristics. Future selected germplasms will be tested at multi location for National Variety Trail test and will be disseminated to the producers/end users.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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REFERENCES

Adam A (2006). Evaluation of Ethiopian Black cumin land races for agronomic characters and oil content at Adet and Woreta, North West Ethiopia.M.Sc. Thesis. Alemaya University. Alemaya.

Ahmed HG, Magaji MD, Yakutu AI, Aliyu L, Singh A (2007). Response of garlic (*Allium sativum* L.) to irrigation interval and clove size in semi-arid. Nig. J. Plant Sci. 2(2):202-208.

Alam MS, Rahim MA, Simon W (2010). Performance evaluation of garlic germplasm under dry land condition. J. Agrofor. Environ. 3(2):43-45.

Alemu H (1998). Farming Systems in Awabel and Machakal Woredas. Constraints and possible interventions through research and extension. Amhara National Regional State/Sida Co-operation in Rural Development. Bahir-Dar.

Brewster JL (1994). Onions and other vegetable Alliums. CAB International, Wallingford, UK.

Central Agricultural Census Commission (CACC) (2002). Report on the preliminary result of area, production, and yield of temporary crops ('Meher' season private peasant holdings). Part II: Ethiopian Agricultural Sample Enumeration, (2001/2002). Federal Democratic Republic of Ethiopia, Central Statistical Authority, Addis Ababa.

Danna D, Lapichino FG. Miceli A (2000). Effect of clove weight on yield and bulb quality of garlic grown for storage. Acta Hortic. 533:589-592.

DZARC (2006). Garlic Production Management. Debrezeit Agricultural Research Center leaflet (Amharic version) Debrezeit Ethiopia.

EARO (2004). Ethiopian Agricultural Research Organization Directory of Released Crop Varieties and Their Recommended Cultural Practices. Addis Ababa, Ethiopia.

Falconer DS (1981). Introduction to Quantitative Genetics. 2nd ed. Longman Inc., New York.

Food and Agriculture Organization of the United Nations Statistics (FAOSTAT)(2015). Area and production of crops by countries.

Fikreyohannes G (2005). Effects of clove weight and plant density on the bulb yield and ield components of garlic (*Allium sativum* L.) in Awabel Woreda, Eastern Gojam Zone. MSc. Thesis Presented to the School of Graduate Studies of Alemaya University.

Fritsch RM, Friesen N (2002). Evolution, domestication and taxonomy. pp. 5-30. In: Rabinowitch HD, Currah L (Eds.). Allium crop science: Recent advances. CAB International, Wallingford, UK.

Getachew T, Asfaw Z (2000). Achievements in shallot and garlic research. report. No.36. Ethiopian Agricultural Research Organization, Addis Ababa. Ethiopia.

Gome KA, Gomez AA (1984). Statistical Procedures for Agricultural Research. International Rice Research Institute, John Wiley & Sons, New York. pp. 139-240.

Islam J, Islam MA, Akter ST, Saha SR, Alam MS, Hasan MK (2004). Performance Evaluation of Some Garlic Genotypes in Bangladesh. Asian J. Plant Sci. 3:14-16.

Islam MJ, AK M, Hossain M, Khanam F, Majumder UK, Rahman MM, Rahman MS (2007). Effect of Mulching and Fertilization on Growth and Yield of Garlic at Dinajpur in Bangladesh. Asian J. Plant Sci. 6(1):98-101.

IPGRI, ECP/GR, AVRDC (2001). Descriptors for Allium (*Allium* spp.). International Plant Genetic Resources Institute, Rome, Italy; European Cooperative Programme for Crop Genetic Resources Networks (ECP/GR), Asian Vegetable Research and Development Center, Taiwan.

Jim H, Martinez C, Wyman N (2003). Estimating and Interpreting Heritability for Plant Breeding: An Update. Estimating interpreting heritability plant breed. Rev. P 22.

Johnson HW, Robinson HF, Comstock RE (1955). Estimates of genetic and environmental variability in soybeans. Agron. J. 47(7):314-8.

Keusgen M (2002). Health and AlliumsIn: Rabinowitch, HD, Currah L (Eds.). Allium crop science: Recent advances. CAB International, Wallingford, UK. pp. 357-378.

Koike ST, Smith RF, Davis RM, Nunez JJ, Voss RE (2001). Characterization and control of garlic rust in California. Plant Disease 85:585-591.

Lemma D, Herath E (1994). Agronomic studies on Allium. In: Herath and Lemma (Eds.). Horticultural research and development in Ethiopia. Proceeding of the 2nd national horticultural workshop of Ethiopia. 1-3 December 1992. Institute of Agricultural Research and Food and Agriculture Organization. Addis Ababa, Ethiopia. pp. 139-145.

Mayer D, Deshmukh VV (2003). Nutritional requirement of Fusarium wilt of chickpea. J. Crop Res. 25(1):197-199.

Miller PAJ, Williams C, Robinson HF, Comstock RE(1957). Estimets of genotypic and environmental variances in upland cotton and their implications inselection. Agron. J. (50):126.

Metasebia M, Shimelis H (1998). Proceeding of the 15th Annual research and extension review meeting, 2 April 1998. Alemaya Research Centre. Alemaya University of Agriculture.

Mohibullah K (1991). Studies on major diseases of bulb vegetables (onion and garlic) in NWFP. Final Technical Report Agricultural Research Institute Tarnab, Peshawar.

Rabinowitch HD, Brewster JL (1990). Onions and Allied Crops. Vol. II. CRC press, Boca Raton. Florida.

Rabinowitch HD, Currah L (2002). Allium Crop Science: Recent Advances. CABI Publication, London.

Rubatzky VE, Yamaguchi M (1997). World Vegetables. Principles, production and nutritive values. 2nd ed. Chapman and Hall.

International Thomson publishing, New York, USA.
SAS Institute Inc (2008). SAS/STAT®9.2 User's Guide. Cary, NC: SAS Institute. Inc Cary, USA.www.support.sas.com/documentation/cdl/PDF; (accessed October/10/2011).
Wheeler JB (1969). An introduction to plant diseases. John Willey and Sons Ltd., London. 301 p.
Yeshiwas Y (2017). Effect of Different Rate of Nitrogen Fertilizer on the Growth and Yield of Cabbage (Brassica Olaracie) at Debre Markos, North West Ethiopia. Afr. J. Plant Sci. 11(7):276-281.

Appendix 1. Key for assessment of Puccinial rust and purple blotch in Garlic (Mohibullah, 1991).

0 to 5 rating scale	Percent severity leaf area infected (LAI)	
	Rust	Purple blotch
Highly resistant	1-4	1-4
Resistant	5-10	5-10
Moderately resistant	11-20	11-20
Moderately susceptible	21-50	21-50
Susceptible	51-80	51-90
Highly susceptible	Above 80%	Above 90%

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Determinants of outlet choices by smallholder onion farmers in Fogera district Amhara Region, Northwestern Ethiopia

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Market outlet choice for small holder onion producers is mandatory, since onion crop is a perishable horticultural crop. This study was aimed at assessing determinant of market outlet choice by smallholder onion farmers in Fogera District of Ethiopia. A stratified random sampling technique was employed, to select 150 onion producers in the study area. Multivariate probit model was employed to identify the factor affecting onion market outlet choices. The result of multivariate probit model showed that literacy status, owning transport facility, livestock holding, onion yield and access to extension service significantly influenced the choice of onion market outlet. The common underlying factors of market channel choice were also identified. Based on the results, the study recommended that the government and stakeholders should focus on strengthening the existence of formal and informal education, onion production system, improving extension system, strengthening the existing rural-telecom and rural-urban infrastructure development and improving crop-livestock production.

Key words: Onion, determinant, channel choice, multivariate probit model.

INTRODUCTION

Onion is one of the most important horticultural crops produced on smallholder farmers in Ethiopia. The onion crops have contributed to Ethiopian economy by exports of bulbs and cut flowers (Desalenge and Aklilu, 2003). Onions can be produced throughout the year in Ethiopia due to the mild climate and the rainy season that provide water for irrigation. The area coverage of onion also increase from time to time because of it high profitable per area and availability of small scale irrigation. Onion is produced both under rain fed and irrigation. In Ethiopia, onion production under irrigation constitutes much of the area than rain fed. According to central statistics agency (2008) 453,608.8 (ha) was covered by vegetable of which onion covered a total of 15,628.44 ha. The estimated annual production of vegetable was 18,124,613.5 quintal (Qt). Among these, onion constituted 1,488,548.9Qt.

Despite an enormous potential and a favorable environmental and socioeconomic advantage, the

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average yield of onion in the Ethiopia is low as compared to other African courtiers due to use of low level of improved agricultural technologies, risks associated with weather conditions, diseases and pests, poor management etc (EIA, 2012; Aklilu, et al., 2015). Moreover farmers living in the fogera district produce large amount of vegetables every year. For instance, in 2014 production year the district contributes 2, 500,908 quintals onions with 10,258 hectares of land coverage of onion crop. This indicates that the district contributes the regional onion production.

Onion productions in Fogera district are producing mainly for market demand by irrigation during dry season. Despite onion is an economically important crop, onion market channel choices study have not yet been undertaken and assessed in the study area. In order to maximize the benefits that they may earn, farmers have to make appropriate decisions as to where they should sell their product. However, there are various factors that affect households' decision to select appropriate channel for delivering their products to the market. Identifying these factors is very important in terms of pinpointing possible areas of interventions that may help farmers to maximize benefits out of their onion production and marketing activities. The study attempts to identify marketing channels of onion and factors affecting these outlet choice decisions by onion producer's households in fogera districts of South Gondar zone Ethiopia.

MATERIALS AND METHODS

Descriptions of study area

This study was conducted in south Gondar, specifically in Fogera district. It is one of the 126 districts in the region. It has an area of 117,405 hectares divided administratively in to 32 Kebeles (30 rural and 2 urban). The population size was 233,529. The total number of households who engaged in agriculture was 42,746 of which 26,277 are onion producers. The capital is Woreta located at the North East on the main road to Gondar from Bahir Dar (Fogera district agriculture office, 2015).

The district is known for its plain nature where flat land accounted nearly 76%. The mean annual rainfall is 1216.3 mm, with Belg and Meher cropping seasons. Its altitude ranges from 1774 up to 2410 masl allowing a favorable opportunity for wider crop production and better livestock rearing (IPMS, 2005). The current land use pattern includes 59.03% cultivated land, 22.73% pastureland, 18.24% water bodies and the rest for others (Fogera district agriculture office, 2015). Most of the farmland was allocated for annual crops where cereals covered 52,759.99 hectares; pulses cover 9819.98 hectares; oil seeds 6137 hectares; root crops 1034.29 hectares; and vegetables 882.08 hectares. The major crops include teff, maize, finger millet and rice in order of area coverage (Fogera district agriculture office, 2015).

Source of data, methods of data collection and sampling procedure

In this study both quantitative and qualitative were collected from primary and secondary sources. The cross-sectional survey was conducted using structured questionnaire, key informant interviews, and focus-group discussions. Focused group discussions were held and key informants were interviewed from different organizations. The sample frame of the study was the list of small farmers in Fogera district and Kebeles Administrations (KAs). A stratified stage sampling technique was used to draw sample units.

In the selection process, Fogera districts agricultural office experts were consulted. There are two urban and 30 rural Kebeles in the district, out of which 12 administrative Kebeles are producing onion. These Kebeles were selected purposively and stratifies based on agro ecology (lowland and upland agro ecology). From each of agro ecology, two Kebeles Administrations (KAs) were randomly selected based on lottery method (Four KAs were selected). Then, the intended sample size from each sample Kebeles were determined proportionally to household size of onion grower farmer. Finally using the household list of small onion producers, the predetermined size which is 150 of the sample farmers from each Kebeles were randomly selected using systematic random sampling technique.

Method of data analysis

Producers are more likely to choose the right mix of market channels to increases maximize sales and help to reduce some risks than a single market channel. Different studies in Africa used different empirical methods to analyze the determinants of choice of market channels. Most commonly used analytical approaches include discrete choice regression models like the binary probit or Logit (Bongiwe and Micah, 2013), Multinomial probit or Logit (Mamo and Degnet, 2012; Berhanu et al., 2013; Tewodros, 2014; Mukiama et al., 2014; Mekonen, 2015), other empirical studies used Tobit (Anteneh et al., 2011).

The limitation of previous studies on choice of market channels are, they do not consider the possible inter-relationships between the various market channels (Green, 2008). These studies mask the reality faced by decision makers, who are often faced with the alternatives that they may be choose simultaneously and/or sequentially as complements, substitutes or supplements. Some recent empirical studies of market channels choice decisions assume that, farmers consider a set (or bundle) of possible channel choices that maximizes their expected utility (Hoffman and Duncan 1988; Arinloye et al., 2012, 2015). Thus, the selection decision is inherently multivariate and attempting univariate modeling excludes useful economic information contained in interdependent and simultaneous choice decisions. Based on this argument, the study adopted multivariate probit (MVP) econometric technique to simultaneously model the influence of the set of explanatory variables on each of the different market channel choices, while allowing the unobserved and/or unmeasured factors (error terms) to be freely correlated (Belderbos et al., 2004). The correlation may be positive and negative correlation between different market channel choices (Belderbos et al., 2004).

The selection of market outlet i by farmer *j* is Y_{ij}^{A} defined as, the choice of farmer *j* to transact in Market channel i $(Y_{ij}^{A}=1)$ or $(Y_{ij}^{A}=0)$ expressed as follows:

$$Y_{ij}^{A} = \begin{cases} 1 if Y_{ij}^{A} = X_{ij}^{A}\alpha_{ij} + \varepsilon^{A} \geq 0 \Leftrightarrow X_{ij}^{A}\alpha_{ij} \geq -\varepsilon^{A} \\ 0 if Y_{ij}^{A} = X_{ij}^{A}\alpha_{ij} + \varepsilon^{A} < 0 \Leftrightarrow X_{ij}^{A}\alpha_{ij} < -\varepsilon^{A} \end{cases} \quad (1)$$

Where α_{ij} is a vector of estimators and ε^{A} is a vector of error terms under the assumption of normal distribution, Y_{ij}^{A} is the dependent and variable for channel choice of assembler, wholesaler and retailers, and X_{ij}^{A} is the combined effect of the explanatory variables.

Univariate probit estimation of choice of each type of market outlet would be misleading for the expected problem of simultaneity. The selection of one type of market outlet would be dependent on the selection of the other, since smallholder farmers choice decisions are interdependent, suggesting the need to estimate them simultaneously. To account for this problem, a seemingly unrelated multivariate probit simulation model was employed (Long 1997; Cappellari and Jenkins 2003; Degye et al., 2013; Arinloye et al., 2015)

$$Assem_j = X_1^{'}\beta_1 + \varepsilon^A$$
$$Whole_j = X_2^{'}\beta_2 + \varepsilon^B$$
$$\text{Re}ta_j = X_3^{'}\beta_3 + \varepsilon^C \quad (2)$$

$$\begin{pmatrix}\varepsilon^A \\ \varepsilon^B \\ \varepsilon^C\end{pmatrix} ......N\left[\begin{pmatrix}0\\0\\0\end{pmatrix}\begin{pmatrix}1 & \rho_{12} & \rho_{13}\\ \rho_{21} & 1 & \rho_{23}\\ \rho_{31} & \rho_{32} & 1\end{pmatrix}\right] \quad (3)$$

$$E\left(\varepsilon/X\right) = 0$$
$$Var\left(\varepsilon/X\right) = 1$$
$$Cov\left(\varepsilon/X\right) = \rho \quad (4)$$

Where $Assem_j$, $whole_j$ and $Reta_j$ binary variables take value 1 when farmer j selects an assemblers, wholesalers and retailers respectively, and 0 otherwise; x_1 to x_3 are vectors of independent variables determining the respective channel choices variables; β's are vectors of simulated maximum likelihood (SML) parameters to be estimated; ε^A to ε^C are correlated disturbances in a seemingly unrelated multivariate probit model; and ρ's are tetrachoric correlations between endogenous variables.

In the trivariate case there are eight joint probabilities corresponding to the eight possible combinations of successes (a value of 1) and failures (a value of 0). If we focus on the probability that every outcome is a success for instance, the probabilities that enter the likelihood function of the market channel choices simulation are explained as

$$\Pr\left(Assem_j = 1, Whole_j = 1, \text{Re}ta_j = 1\right)$$
$$= \phi_3\left(\beta^{'}_1 X_1, \beta^{'}_2 X_2, \beta^{'}_3 X_3, \rho\right)$$
$$= \Pr\left(\varepsilon^A \le \beta X_1, \varepsilon^B \le \beta X_2, \varepsilon^C \le \beta X_3\right) \quad (5)$$

Where ϕ_3 is the multivariate normal density function.

Dependent variable

Market outlets (MktOut): Marketing channels or outlets are those pathways where agricultural products pass through to reach consumers. i.e the actual buyers or the ultimate user of onion producer. Therefore, the dependent variable for the model is more than two binary outcomes taking value 1 when farmer j selects an assembler, wholesaler, and retailer's market channels, respectively, and 0 otherwise.

Independent variables

Literacy status of the household head (EDU): It assumes a value of 1 if the household head attained formal education and 0 otherwise. It is believed that if a farmer attained formal education of any level there is a possibility that the farmer would choose appropriate channels. This is supported by Bongiwe and Micah (2013) as a result; education is hypothesized to make better decisions in channel choice.

Total livestock holding (TLU): This is a continuous explanatory variable measured in tropical livestock unit. Farmers who specialize in livestock assumed to affect farmers decision in choice of market outlet. Study by Rehima (2007) on pepper marketing showed that, TLU showed a negative sign on quantity of pepper sales. TLU is expected to have positive effect on market outlet choice in this study.

Ownership communication devices (OwnComm): This is the dummy variable value 1 for own communication device and 0 otherwise. Ownership of communication device by the household head is used as a proxy to measure market information access. Farmers who own communication device such as radios, mobiles and TV have better access to extension used to adopt better market outlet. In this study it is hypothesized that ownership of communication device affect onion market outlet positively.

Ownership of transport assets (OwnTrans): This is the dummy variable value 1 when farmers own transport asset and 0 otherwise. Specifically vehicles, carts and animal transports would be used to measure the availability of product transportation facilities by households. This variable expected influence market outlet choice of onion producers (Key et al., 2000).

Access to market information (Distance to urban centers): This is a continuous variable using the best proxy a proximity to urban centers measured in Kms or walking minutes (continuous). Farmers nearer to urban centers are more likely to be informed. Jari (2009) stated that availability of market information boosts confidence of household who are willing to participate in the market and affect market outlet. The better information farmers have about the product market, the better would be the choice he/she makes on the channel selection. This is supported by Jeffrey et al. (2009) as a result; access to market information is hypothesized to affect outlet choice decision by onion producers.

Lagged market price (LMP): This is also the variable, measured in log normalized price of onion (Birr) per quintal and is expected to affect the market channel choice. Because, lagged prices can stimulate production and thus marketable supply of onion for the next year producers are motivate to sell their product to market outlet. According to Myint (2003), if prices in one year are bad, farmers will often respond by planting less in the next year. This will lead to lower production and higher prices, thus encouraging more plantings in the following year and a consequent fall in prices. This cyclical nature of production and prices is quite common. This makes producers to supply onion product directly related with price offer. As a result, this variable hypothesized to affect outlet choice decision by onion producers.

Access to credit (CRE-ACC): This is dummy variable taking value of one if farmers takes loan and zero otherwise, which indicates credit taken for onion production and marketing. Access to credit would enhance the financial capacity of the farmer to purchase the inputs, thereby increasing onion production and market share size. Therefore, it is hypothesized that access to credit would have positive influence on level of production and sales. Therefore, farmers who do have access to credit do produce more production this will push farmers to sell to different market outlet.

Agro ecology (AgroEco): This variable is a dummy taking the value zero if the agro ecology is upland and one if the agro ecology is lowland, which consists of a number of characteristics of the agro ecology. Tura et al. (2016), founded that agro ecology positively and significantly affects the probability of market participation by teff smallholder farmers. This variable hypothesized to have relationship with outlet choice decision of onion producers.

Income from non/off farming activities (NOFI): This variable is a dummy taking value one if the farmers are involve in Non/Off Farming activities and zero otherwise. Farmers who gain more income from non/off farm income want to supply their onion to any nearest market outlet with low price. This income may strengthen farming activity on one side and may weaken it on the other side. As result, off/non farm income is hypothesized to influence market outlet choice decision of onion producers.

Access to extension service (AExte): this is also a dummy variable which takes the form of one if farmers have access to credit and zero otherwise. Farmers who has access to extension improves household intellectual capital, which improves vegetable (onion) production, divert production resources to markets and choice market channels. Therefore, access to extension has direct effect on market channel choice decision by onion producers.

Onion yield (productivity): It is a continuous variable measured in quintals per hectare. Farmers who produce more onion yield per hectare are expected to supply more onion and choice market channels to the market than those who produce less. Therefore, the variable is hypothesized to affect channel choice positively.

Production costs (Prodcost): This is a continuous variable which measures the log normalized value of all inputs for growing and sale onion crops (Birr) per quintal per season. To produce an onion, these inputs would include so many units of seed, fertilizer, irrigation water, labor, transport and other cost, etc. According to Charity (2015) the cost of information significantly influenced direct sale at the market and brokers at positively and negatively respectively. In this study it is hypothesized that production cost affect market choice either positively or negatively.

RESULTS AND DISCUSSION

Characterization of households by market channel choices

Onion producers in the study area sell their product into three market outlet. These were wholesalers which accounts for 66.7% of total sells followed by assemblers (40%) and retailers (21.33%). But the role of agricultural cooperatives in smallholder farmers marketing is recognized as essential, they are limited onion producers reported cooperatives as alternative market outlet in their onion marketing which is 8% of the total sample households. This should be seen as serious policy concern for the government and other stakeholders in this sector.

The mean household characteristics by onion market outlets are provided in Table 1 below. The mean age of household heads which had access to assembler, wholesaler and retailer onion market outlets was 43.8, 43.28 and 44.87 years, respectively. However, age of household does not statistically influence the choice of market channels. The average distance travelled to onion producers sold to the assembler market outlet was on average 2.03 km away from the nearest market while those sold for wholesalers and retailers market outlet are located on average 3.06 and 2.3 km away from home respectively. The finding (Table 1) indicates that distance from nearest urban market statistically influence choice of market outlet at 5% level. The average lagged onion market price offered by retailer market outlet was ETB 602.5 per quintal which is higher than price offered by other market outlets. On average 179, 122 and 205.5 quintal of onion yield per hectare was accessed by assembler, wholesaler and retailers market outlets, respectively. The finding indicates that onion yield or productivity statistically influence choice of market channels at 5%.

Proportion of household characteristics by onion market outlets is given in Table 2. The proportion of the respondents who sold to assembler (55%), wholesaler (53%), and retailer (62.5%) market outlets had attending formal and informal education. The results in Table 2 on transport ownership indicate that 16.67, 32 and 18.75% of market participants used assembler, wholesaler and retailer, respectively as the choice of marketing outlets. Observed difference in ownership of transport influence the choice of market outlet and was found to be statistically significant at 10% level. This implies that the majorities of who sold to wholesaler owned transport. The results on ownership of communication device indicate that 70, 52 and 78.12% of market participants used assembler, wholesaler and retailer market outlet, respectively. The observed difference in ownership of communication device influence the choice of market outlet and it was found to be statistically significant at 1% level. This means, the majorities of who sold their onion to assembler and retailer owned communication device. In terms of Non/off-farm activities only 26% onion producers sell their product to wholesaler market outlet which involved in non/off farm activities, whereas 51.67 and 56.25% of respondents sell their product to assemblers and retailers market outlet were participated in non/off-farm activities, respectively. The finding indicates that non/off farm statistical influence market outlet choice at 1% significant level.

Table 1. Mean household characteristics by onion market outlets.

Variables	Mean (Std) of market outlets			F- value
	Assemblers	Wholesalers'	Retailers	
Age of household head	43.8 (9.91)	43.28(10.76)	44.87(9.75)	0.29
Distance to the nearest urban market	2.03(1.62)	3.06(2.47)	2.30(1.56)	5.05**
Number of livestock owned in TLU	4.75(2.45)	4.80(2.50)	4.87(2.71)	0.02
Production cost	13514(11839)	13388(11883)	10989(6299)	0.64
Onion lagged price	551(139)	602(241)	602.5(252)	1.56
Onion yield(productivity)	179(208.5)	122(137.5)	205.5(233)	3.53**

Note: *** significant at 1%, ** at 5% and * at 10%. Results in parenthesis are standard deviations.

Table 2. Proportion of household characteristics by onion market outlets.

Variables	Category	Assemblers (%)	Wholesalers (%)	Retailers (%)	Chi-square value
Literacy status of household head	Literate	55	53	62.5	0.89
	Illiterate	45	47	37.5	
Ownership of transport asset	Yes	16.67	32	18.75	5.50*
	No	83.33	68	81.25	
Ownership of communication device	Yes	70	52	78.12	9.40***
	No	30	48	21.88	
Access to credit	Yes	38.33	22	31.25	5.02*
	No	61.67	78	68.75	
	No	15	22	15.62	
Participation in non/off farm income	Yes	51.67	26	56.25	15.14***
	No	48.33	74	43.75	
Agro ecology	Upland	56.67	64	53.13	1.57
	Lowland	43.33	36	46.88	
Access to extension service	Yes	90	89	96.68	1.80
	No	10	11	3.32	

Note: *** significant at 1%, ** at 5% and * at 10%.

Finally about 38.33, 31.25 and 22% of respondents sell their product to assemblers, retailers and wholesalers, market outlet had taken credit for onion production and marketing respectively. The chi-square result showed that access to credit was statistically significance with market outlet choice at 10% significance level.

Determinants of market channel choice

The expected multivariate interdependence of selection of particular market channel of assembler, wholesaler and retailers was accounted for by employing the multivariate Probit model (Table 3).The Wald test was used to test the model fits, the data is statistically significant at 1% significance level, which implied that the subsets of coefficient are jointly significant and the independent variable include in the model is acceptable.

Moreover the likelihood ratio test in the model *($\rho 21 = \rho 31 = \rho 32 = 0$)* is significant at 1%. Therefore, the null hypothesis that all the ρ (Rho) values are jointly equal to 0 is rejected, indicating the goodness-of-fit of the model or implying that the decisions to choose these market channels are interdependent. Hence, the use of multivariate probit model is justified to determine factors influencing choice of market channels. Further, there are

Table 3. Multivariate probit Simulation results of market channel choice.

Variables	Coefficients (channel choice equations)		
	Assemblers (1)	Wholesalers (2)	Retailers (3)
Agro ecology (Lowland)	0.77**	-0.18	0.17
Distance to nearest urban market	-0.29***	0.30***	-0.18*
Literacy status of household head(literacy)	-0.45*	-0.23	0.19
Ownership of transport assets(yes)	-0.80**	-0.90***	0.54*
Ownership communication devices(yes)	0.72**	-0.37	1.03***
Non/off farm income (yes)	0.98***	-0.83***	0.75**
Productivity(onion yield)	0.001*	0.001	0.001
Log-Lagged onion market price	-1.82**	1.78*	-2.31**
Access to credit (yes)	0.72**	-0.80***	0.33
Log of production cost	-0.41	0.88**	-1.27**
Tropical livestock unit	0.01	-0.08*	0.07
Access to extension service (yes)	0.20	-0.21	1.52**
Age of household head	0.01	-0.001	0.02*
Constant	5.42*	-7.34**	6.80*
Predicted probability	0.390	0.693	0.205
ρ 21		- 0.92***	
ρ 31		0.67***	
ρ 32		-0.73***	
Number of simulations (draws)		5	
Wald chi2(39)		80.10***	
Likelihood ratio test of independence		*P21 = ρ31 = ρ32 =0, chi2(3) = 78.44* ***	
Joint probability (success)		0.033	
Joint probability (failure)		0.035	

Note: ***, **, and * significant at 1%, ** at 5% and * at 10% probability level respectively.

differences in market channel choice behavior among farmers, which are reflected in the likelihood ratio statistics.

The ρ values (*ρij*) indicate the degree of correlation between market channel choices. The *ρ21* (correlation between the choice for assembler and wholesaler market outlet) and *ρ32* (correlation between the choice for retailer and wholesaler market outlet) are both negative and statistically significant at the 1% significance level (Table 3). The study revealed that farmers delivering to the assembler are less likely to deliver to wholesaler (*ρ21*). Equally, farmers who involved in retailer market outlet are less likely to send their onion to the wholesaler (*ρ32*). Moreover the Simulated maximum likelihood estimation results suggested that there was positive and significant interdependence between farmers selection of market outlet of retailer and assembler which implied that the *ρ31* (correlation between choice for assembler and retailer) are positively and statistically significant at 1% level. Finally the study reveals that assembler market outlet with wholesaler outlet and retailer and wholesaler market outlet are competitive to each other in the study areas. However correlation between assembler and retailer market outlet indicates complementary relationship (Table 3).

The marginal success probability for each equation (market channel decision) is reported below. The likelihood of choosing retailer is relatively low (20.5%) as compared to the probability of selecting assembler market channel (39.0%) and selecting wholesaler market channel (69.3%). This is good evidence because farmers were not interested in selling their products to retailer market channel even if they get good price than other market channel due to marketing cost.

If onion farmers chose all three market channels, their joint probabilities of choosing these market channels would be only 3.3%. It was unlikely for farmers to choose all three market channels simultaneously. This was justified either by the fact that simultaneous chose of all market channels was unaffordable for the smallholders onion farmers, or that all three market channels were not simultaneously accessible in the study areas. However, their joint probability of not choosing all three market channels was 3.5%, implying that the households were more unlikely to fail. This evidence suggests that choosing the right mix of market channels is determined by different factors for each market channels. The finding was also consistent with Degye et al. (2013) in their study on food security and agricultural technologies interaction study in Ethiopia.

Distance to nearest urban market: The coefficient of distance to nearest urban market was found to have a direct relationship with wholesaler onion market outlets and significant at 1% probability level. Whereas the likelihood of choosing retailer and assemblers market outlet statistically and negatively influenced by distance to nearest urban market at 10 and 1% probability level, respectively. This indicated that farmers whose residences are far from nearest urban market are more access to sell their product to wholesaler market outlet and less to sell to retailer and assembler outlet.

Agro ecology: Agro ecology was found to be positively and significantly affected in assembler onion market outlet at 5% significance level. As the agro ecology becomes lowland the likelihood of onion producers to sell their produce to assembler outlet would be decrease as compared to upland. The reason may be is the most of rural assemblers live either rural lowland Kebeles namely Woreta Zuria, Awa, or Woreta. This forced onion producers to sell to assemblers in the market.

Literacy status of household head: Literacy status of households was affected by assembler channel choice significantly at 10% and was negatively and not expected. It was expected that the literacy status of household would positively influence the market channel choice. This implied that the probability of selling onions to assembler's market channel would be decrease than the probability of selling to retailer market channel choice. This result consistent with Bongiwe and Micah (2013), Mutura et al. (2015), were found that education affect vegetable and diary market channel choice negatively, respectively.

Ownership of transport assets: ownership of transport influenced the choice of assembler and wholesaler outlet negatively and significantly at 5 and 1%, respectively; and choice of retailer outlet positively and significantly at 10% significance level. This might be farmers who have transport facility that could supply their product to local market center and sell to retailers directly by getting better price. The result concurs with argument of Chalwe (2011) who stated that the availability of on-farm transport increases the probability of transporting goods to private traders and retailers in the market.

Ownership communication devices: Another market characteristic is ownership of communication device which had a positive and significant influence on the choice of assembler and retailer outlet at 5 and 1% probability level, respectively. The positive sign show that farmers who have own communication device are more likely to sell onion to assembler and retailer outlet compared to those farmers who had not. This might be due to the reason that communication device is used to access information and knowledge to strengthen onion production and marketing. This result is consistent with Key et al. (2000).

Productivity (onion yield): Onion yield produced by farmers was associated with a positive effect on farmer's choices among alternative onion market channels. An increase in farmer's onion yield results in an increase in the probability of choosing assembler market channel at 10% level of significance. The implication is that if the quantity of onion to be produce is large farmers' search, a market outlet buys large volume with high price. But, if the quantity to be produce is low; farmers are not forced to search price and market information. This result is consistent with Maryam (2015) which showed that yield was associated with a positive effect on farmer's choices among alternative rice output market.

Non/off farm income: Non/off farm income affect the probability of choosing assembler and retailer market outlet positively at 1 and 5% levels of significance, respectively; and choice of wholesaler outlet negatively and significantly at 1% significance level. This indicates that onion farmers who are involved in non/off farm activities are more participated to sold their product to retailer and assembler market outlet as compared to onion farmers who didn't participated in off/non farm income activates. Moreover farmers who are involved in off/non-farm activities are less likely to send their onion to wholesaler outlet as compared to farmers who not. The possible explanation is that as the farmer involved in non/off farm activities the time he/she has to spare for marketing of agricultural activities and to produce marketable surplus is less, hence this decreases the probability of participating in wholesaler market channel which is a larger market compared to retailer and assembler market outlet. This result is consistent with Tewedrows (2014) who found that farmers involved in non/off farm activities affect retailer market participation negatively.

Access to credit: The probability of choosing assembler and wholesaler was also positively and negatively affected by access to credit at 10 and 5% levels of significance, respectively. As the farmers have access to credit, onion producer are more likely to sell onion to assembler outlet as compared to producers who not. In addition as the farmers have access to credit, the probability of participating in wholesaler market channel will decreases. The possible reason that farmers who choose assembler market outlet have better access to formal credit than wholesalers market outlet. The result is consistent with the findings by Mussei et al. (2001).

Lagged onion market price: The coefficient of onion lagged price variable was found to have an inverse relationship with the probability supplied to assembler and retailer's market outlets and significant at 5% probability level but positively and a significant influence on the choice of wholesaler's market outlet. The coefficient indicates that farmers are less likely to sell onion to assemblers and retailers outlet as lagged onion market price increase. The possible reason could be that the average onion lagged market price of wholesaler was high as compared to other market outlet among sample households. This result is consistent with the result obtained by Berhanu et al. (2013) who found that access to milk market outlet price negatively affect accessing cooperative milk market outlet as compared to individual consumer milk market outlet.

Production costs: production costs significantly affects the probability of choosing wholesaler market outlet positively at 5% significance level. This implied that an increase in production cost incurred by onion producers increases the probability of choosing wholesaler market outlet over retailer and decreases the probability of choosing retailer market outlet. The possible reason that the longer the distance, the higher the production costs, hence the channel which is associated with higher production costs reduces farmer's gross margins. This research finding is consistent with the results of Mutura et al. (2015).

Tropical livestock unit: Livestock holding affects the likelihood of choosing wholesaler market outlet negatively and significantly at 10% significance level. This implies that the likelihood of choosing wholesalers market outlet decreases, if ownership of livestock TLU increase. The possible reason is that livestock production and onion production compete for the scarce land and water resources, necessitating that farmers often have to make choices. This leads to reduced onion production and market channel choices.

Access to extension service: Access to extension service had positive sign and significantly affects the choice of retailer market outlet at 5% significance level. Farmers who have an access to extension service would be sold their product to retailer market outlet than farmers who did not have access to extension service. This implies that extension service increased ability of farmers to improve production and market information, thereby increasing output and ability to choose the best market outlet which gives high price. This result is consistent with Abraham (2013) who found that extension service affect choice of collector and retailer market outlet negatively.

Age of household: Age of household head was to be statistically significant at 10% significance level and positively influenced choice of retailer market outlet by smallholder farmers. The results implied that, as age of household head increases the probability of choosing retailer market outlet increase. This implies that, older farmers may take their decision to choose better market outlet which gives higher price more easily than the young farmers, because older people might have marketing experience, accumulated capital or a long term relationship with their clients or might have preferential access to credit due to their age, availability of land, or family size.

CONCLUSION AND RECOMMENDATIONS

Market outlet choice decision of onion is the most important elements. The main objective of the study is to analyze the determinant of market outlet choice by smallholder onion farmers in Fogera district. Therefore, Multivariate Probit Model (MVP) was employed to analyze factors determine choice of onion market outlet in the study areas. Onion producers in the study area sold their product through alternative market outlets. Farmers were classified into three categories according to their outlet choice decision but are correlated: those farmers who sold their product to wholesalers (66.7%); those who have supplied most of their produce to assemblers (40%); and those farmers who have supplied most of their produce to retailers (21.33%). Multivariate probit model results confirm that agro ecology, distance to nearest urban market literacy status, ownership of communication device and transport asset, onion yield, off/non-farm income, access to credit, access to extension service, production cost, age of household, lagged price of onion were an important factor that affects the probability of choosing market outlet choices.

From these findings, the following policy implications of the variable are extension interventions that should train old aged households to produce high quality products and choice market channels. Appropriate policies should strengthen the existing provision of formal and informal education through facilitating all necessary materials to the rural farming households in general and to the study area in particular, policies that would improve the existing onion production and productivity system. This district should establish the vegetable market centre nearest to the farmer's residence or production area. Moreover policies and strategies should place more emphasis on strengthening the existing communication device (ownership of radio, TV, mobile), rural telecom and rural-urban infrastructure development of the study areas, by the regional and Local Government. Finally, the study suggested strengthening the existing crop-livestock production system through providing improved health services, better livestock feed (forage), targeted credit and adopting agro-ecologically based high-yielding breeds and disseminating through artificial insemination in the area.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Abraham T (2013). Value chain analysis of vegetables: The case of Habro and Kombolcha Woredas in Oromia Region, Ethiopia. M.Sc thesis presented to the school of graduate studies, Haramaya University. P 129.

Aklilu N, Yitagesu K, Abiy A, Tigist A, Kidane D (2015). Onion Production for Income Generation in Small Scale Irrigation Users Agro-pastoral Households of Ethiopia. J. Hortic. 2:145.

Anteneh A, Muradian R, Ruben R (2011). Factors Affecting Coffee Farmers Market Outlet Choice in Ethiopia. Centre for International Development Issues Nijmegen, Radboud University, the Netherlands.

Arinloye DDAA, Hagelaar G, Linnemann AR, Pascucci S, Coulibaly O, Omta OSFW (2012). Multi-Governance Choices By Smallholder Farmers In The Pineapple Supply Chain In Benin: An Application Of Transaction Cost Theory. Afr. J. Bus. Manage. 6:10320-10331.

Arinloye DDAA, Stefano P, Anita RL, Ousmane NC, Geoffrey H, Onno SWFO (2015). Marketing Channel Selection by Smallholder Farmers. J. Food Prod. Mark. 21(4):337-357

Belderbos R, Carree M, Diederen B, Lokshin B, Veugelers R (2004). Heterogeneity in research and development cooperation strategies. Int. J. Ind. Org. 22:1237-1263.

Berhanu K, Derek B, Kindie G, Belay K (2013). Factors Affecting Milk Market Outlet Choices in Wolaita Zone, Ethiopia. Holota Agricultural Research Center, EIAR, Addis Ababa, Ethiopia. Afr. J. Agric. Mark. 1(2):024-031.

Bongiwe GX, Micah BM (2013). Factors Affecting the Choice of Marketing Channel by Vegetable Farmers in Swaziland, Sustain. Agric. Res. 2:1.

Cappellari L, Jenkins SP (2003). Multivariate probit regression using simulated maximum likelihood', Stata J. 3(3):1-17

Central Statistical Authority (2008). Report on Area and Production of Crops, (Private Peasant Holdings, Meher Season), Addis Ababa, June, 2008. Stat. Bull. P 417.

Chalwe S (2011). Factors Influencing Bean Producers' Choices of Marketing Channels in Zambia. M.Sc thesis. University of Zambia.

Charity MM (2015). Effect of transaction costs on choice of mango marketing channel and income of small-scale farmers in Makueni county, Kenya (Doctoral dissertation, Egerton University).

Degye G, Belay K, Mengistu K (2013). Is food security enhanced by agricultural technologies in rural Ethiopia? Afr. J. Agric. Resour. Econ. 8(1):58-68.

Desalenge L, Aklilu S (2003). "Article title", Research Experiences in Onion Production, EARO Ethiopian Agricultural Research Organization, Research Report No 55.

Ethiopian Investment Agency (2012). Investment opportunity profile for production of fruits and vegetables in Ethiopia. Privatization Agency, Addis Ababa, Ethiopia. Download able at http://www.ehpea.org.et/vege%201.htm, accessed March 10, 2014

Fogera District Agricultural Office (2015). Socio-economic profile description of fogera district of North Gondar, wereta, Ethiopia.

Hoffman SD, Duncan GJ (1988). Multinomial and conditional logit discrete-choice models in demography. Demography, 25(3):415-427.

Jari B, Fraser CG (2009). An Analysis of Institutional and Technical Factors Influencing Agricultural Marketing amongst Smallholder Farmers in the Kat River Valley, Eastern Cape, South Africa. Afr. J. Agric. Res. 4(11):1129-1137.

Jeffrey R, Alwang M, Christie E, Taylor DB (2009). Effects of Access to Information on Farmer's Market Channel Choice: The Case of Potato in Tiraque Sub-Watershed Cochabamba, Bolivia. M.Sc Thesis Agricultural and Applied Economics, Virginia Polytechnic Institute and State University.

Key N, Sadoule E, de Janvry A (2000). Transaction costs and agricultural farmer supply response. Am. J. Agric. Econ. 82:245-245.

Long JS (1997). Regression models for categorical and limited dependent variables (RMCLDV). Thousand Oaks CA: Sage Press.

Mamo G, Degnet A (2012). Patterns and Determinants of Live Stock Farmers' Choice of Marketing Channels: Micro-Level Evidence. Ethiopian Economics Association Research, Addis Ababa, Ethiopia P 55.

Maryam M (2015).Analysis Of Rice Farmers' Access to Output Market and Profit Efficiency in Kano State, Nigeria A Thesis Submitted To The School Of Postgraduate Studies, Ahmadu Bello University, Zaria.

Mekonen A (2015). Determinants of Market Outlet Choice and Livelihood Outcomes of Coffee Producing Farmers: The Case of Lalo Assabi Woreda, Oromiya, Ethiopia. MSc Thesis presented to school of graduate, Haramaya University.

Mukiama BK, Nongluck S, Yaowarat S (2014). Factors influencing vegetable farmer's choice of marketing channel in Khon Kaen, Thailand. Agric. J. 42(4):595-604.

Mutura JK, Newton N, Maina M, Stephen KW (2015). Vertical and Horizontal Integration as Determinants of Market Channel Choice among Smallholder Dairy Farmers in Lower Central Kenya. Asian J. Econ. Empir. Res. 2(2):83-90.

Myint UK (2003). Agricultural Marketing Information System in Myanmar. Approaches, Acts Press, Nairobi, Kenya. J. Agric. Mark. 45(4):24.

Rehima M (2007). Analysis of red pepper marketing: the case of Alaba and Silitie in SNNPRS of Ethiopia. An MSc Thesis Presented to School of Graduate Studies of Haramaya University 153p.

Tewodros T (2014). Analysis of Chickpea Value Chain and Determinants of Market Options Choice in Selected Districts of Southern Ethiopia. J. Agric. Sci. 6:10.

Tura G, Degye G, Tinsae D, Tadesse K (2016). Determinants of market participation and intensity of marketed surplus of teff producers in Bacho and Dawo districts of Oromia State, Ethiopia. J. Agric. Econ. Dev. 5(2):020-032.