Effects of Using the New *Alemayehu's* Row Seeding Technology on Wheat Production as Compared to Broadcasting Sowing Method of Smallholder Farmers at Eight Districts of Arsi Zone

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Abstract

Seed sowing techniques play an important role in the placement of seed at proper depth and spacing, which ultimately affect the crop growth and its yield performance. The selection of suitable sowing methods for wheat production is dependent upon the time of planting, soil types, accessibility and affordability of sowing machine. Therefore, the current study was conducted during 2019/20 at eight selected districts of Arsi zone to find out and investigate the effects of different sowing techniques on yield and yield components of Wheat (*Triticum aestivum* L.) on fields of Smallholder Farmers as Compared to Broadcasting Sowing Method**.** A field experiment was consisted of three sowing techniques (*Bereken Maresha* + full ART set, only ART leveling board + traditional *Maresha* and broadcasting sowing method). The treatments were laid out in randomized complete block design with eight replications. The usage of full ART plus *Bereken Maresha* for sowing showed highly significant ($p<0.01$) effect on grain yield. The maximum grain yield of wheat was obtained from sowing seeds by using full ART + *Bareken Maresha* as compared to both leveling board plus 'Bereken *Maresha'* and broadcasting sowing methods. The yield increment recorded by *Bareken Maresha* plus Full ART set and levelling board plus traditional *Maresha* was enhanced by 25.37% and 18.34%, respectively per meter square than broadcasting sowing method. Therefore, this study recommends carrying out further additional agronomic research over location and time in order to raise wheat yield for the successful promotion and adoption.

Key words: Arsi zone, Broadcasting method, Districts, Sowing methods, Wheat Yield components.

1. Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cash and food crops of Ethiopia, particularly in Arsi zone which occupied the largest crop area. Despite the availability of high yielding varieties for different ecological zones, the average wheat yield of our country is low as compared to other countries of the world. Lower wheat yield could be due to unavailability of recommended varieties seed, delay in planting, inappropriate sowing methods, imbalance use of fertilizers, inefficient soil and water management practices. Especially, agronomic practices are one of the most important factors that influence the production and productivity of small cereal crops. Among these practices, the sowing method of cereal crops is considered a critical factor as it can increase plant population (density of productive tillers) thus leading to higher crop productivity if properly managed (*Tolesa et al., 2014*)

In Ethiopia, smallholder farmers are unable to adopt modern seed driller because the technology is unaffordable by most of farm households.

Adopting seed driller technology is a series challenge for smallholder farmers. As a result, most smallholder farmers in the country use manual broadcasting wheat seeds agronomic practice as the practice is very much cheap, and save farmers' time. Broadcasting sowing method (BCSM) requires higher seed rates than row seeding. Furthermore, broadcasting sowing agronomic practice reduces yields as the scattered emergence and growing of wheat plants makes it difficult to distinguish wheat plants from grassy weeds. Thus, hand weeding and hoeing is difficult, and competition from weeds lowers tillering capacity of the crop that could lead to poor wheat growth and yield that again requires large human labour for weed control. On the other hand, row seeding with the recommended distance between rows can increase the number of productive tillers and also providing sufficient aeration, moisture, sunlight and availability of nutrients needed for proper crop development (Ejegayehu, 2016).

Different studies indicated that row seeding agronomic practices increase yields as compared to BCSM. Study conducted by Ejegayehu (2016) revealed that smallholder farms who had adopted wheat row planting technology on their marginal farm land on average had resulted in 56 quintals (5.6 tons) of wheat yield per ha at a sowing cost of around 4,800 ETB larger than that of use BCSM in a single production year. She found that wheat row planting technology can increase wheat yield from 50 to 80% more as compared to BCSM (Ejegayehu, 2016). In the same way, the mean yield of row planted wheat was higher by 13.9% when compared to the mean yield of BCSM (Tolosa *et al.,* 2014).

Besides BCSM, row seeding with animal drawn row seeders, and using tractor mounted row seeders are already practised in Ethiopia. Tractor mounted row seeders is mainly practiced by state seed enterprises.

Attributable to different advantages of row seeding agronomic practices as compared to BCSM, agricultural policy makers, agronomist, and extension personnel consider row planting as better agronomic practice than the traditional BCSM, regardless of the specific row planting technology employed. Similarly, the Ministry of Agriculture and Livestock Resources gave high importance and actively promoting row sowing of wheat and other cereal crops. Farmers are encouraged to row-seed wheat manually with family labour. As this practice is highly labour-intensive and family labour is limited, the recommended row seeding is impossible for those farm households lacking the required family labour (personal observation).

Despite all these efforts, the row seeded area is estimated to be well below 10% of the total wheat cropped land. There are different factors that explain low adoption rate of row seeding in the country. One of the factors is tractor mounted row seeders are relatively complicated and need a minimum level of technical skills and experience for regularly adjusting and calibrating them, both of which are in short supply. Partly because of this factor much fewer row seeders are available and used than tractor mounted ploughs. High price of row seeders technology is another factor that affects its adoption by smallholder farmers (Zonal agriculture office).

By making and taking many crops growing observations into due consideration, Mr. Alemayehu Wondefrash, a staff member of the GIZGICE-VCC NIRAS–IP designed and developed a simple row seeding technology in 2017. He based his technology on the simple observation that the surface of the fields prepared for broadcasting using the traditional Maresha comprises ridges alternating with furrows. He estimated that if after broadcasting the seed on this inverted V-shaped surface a farmer would level the tips of the ridges, all the seeds laying on the tips would fall into the furrows right and left of ridges together with the soil of the tips, thus creating bands with wheat seed (the furrows) separated by wheat-free bands (the tips of the ridges) (Kahloon *et al*., 12)

Based on the initial test, GICE-VCC Arsi Zone further planned to evaluate the ART with scientific research works. Accordingly, at the start of the main growing season 2018, the GICE-VCC Arsi Zone organised a training course for selected Rotation Based On-Farm Demonstrations (RoBOFD) farmers and extension staff from eight *Woredas* on how to use the ridger, the levelling board and the cultivator. The project's Training/Technical Experts selected the farmers on which RoBOFD plots these devices were to be tested. Immediately afterwards one complete set of equipment (components 1, 2 and 3) named *Alemayehu* Row-Seeding Technology (ART) here after, were provided to each of the Mechanisation Units of the 8 *Woredas* Agriculture Offices.

Then after, researchers of Arsi University had carried out the evaluation of the ART on field experiment in six districts of Arsi zone in 2018 cropping season. The analysis result showed that the use of ART for sowing operation helped the wheat crop to improve its vegetative growth and consequently improved the yield of the crop. Generally, better yields and higher records of most yield related parameters were observed when using the ART at all tested sites in the six districts of Arsi Zone (personal observation).

Even though the results of the 2018 study were very promising, the sample sizes used were very small and limited to only 24(10 ART users and 14 non users) smallholder farmers. Thus, it is very important to use larger experimental areas for carrying out meaningful statistical analysis and investigate the effects of using the New ART on Wheat producing

Smallholder farmers as compared to broad casting sowing method (BCSM). Thus, the study was aimed to investigate effects of new ART set in comparison with farmers' broadcasting sowing method on wheat crop production in eight districts of Arsi Zone.

2. Materials and Methods

2.1.Description of the study areas

The experiment was conducted during 2019/20 main cropping season under rain fed conditions in different agro-ecological zones of the selected eight RoBOFD districts of Arsi Zone: Tiyo, Hitosa, Lode Hitosa, Arsi-Robe, Munesa, Limu-Bilbilo, Digelu-Tijo and Honkolo-Wabe. These districts are similar with the area in which the GICE-VCC project implements which of its field activities aimed at increasing production, productivity and income from growing wheat and fababeans and focused on crop rotation, with all Good Agriculture Practices for these two crops demonstrated on Rotation based On-Farm Demonstrations. The new ART field experiments were carried out on 32 selected main RoBOFDs *kebeles* of eight districts along with BCSM for comparison.

2.2.Treatments and Experimental Design

The experiment consisted of three different wheat sowing techniques (the full ART set + Bereken *Maresh*a (BM), only ART levelling Board + traditional *Maresha*, and Broadcasting sowing method) replicated in eight districts of Arsi zone in 32 sites i.e. four experimental sites from each districts (3*4*8=96). On the first farmers field wheat seed was broadcasted as usual (untreated treatment 3, control); and on the second RoBOFDs wheat field was sown using levelling board + traditional '*Maresha'* (treatment 2) and on the third RoBOFDs wheat field was sown using the full ART + BM (treatment 1). The three treatments (full Art + BM, levelling Board + traditional Maresha and BCSM) were laid out in Randomized complete block design (RCBD) with eight replications. The four fields used for each treatment were considered as a block. In each district the three experimental treatments were repeated, and data were collected and analysed separately for accurate means comparison of each parameters of the experiment.

2.3. Experimental Procedures and Field Management

The experimental fields were ploughed with oxen to a fine tilth three up to four times depending on the soil types and environmental factors of the experimental area; oxen ploughing were made by preferably using the traditional ‘Maresha’. The agronomic data were collected from each experimental plot and farmers’ field for appropriate data analysis and interpretation. The data collections were accomplished by cooperating with RoBOFD households and by employing post graduate students of Arsi University.

2.4. Data Collection and measurements

Days to heading (DH): The number of days was recorded when 50% of the plants reached to their heading stages. This was done by observing randomly the heading shoots within meter square of the three treatment plots side by side.

Plant height (cm): Five plants from one meter square of the central rows of the treatments and untreated plot were randomly selected for measuring plant height at physiological maturity and the average height of five plants were recorded by measuring the plants from the surface of the soil to the tip of the spikes (owns excluded).

Days to Physiological Maturity (DM): The number of days was counted when 90% of the plants in each treated and untreated plot of meter square reached 90% physiological maturity, i.e., when grains are difficult to divide by thumb nail. This was done by observing the colour of the crops in each plot turned to yellow.

Number of effective tillers: the number of productive tillers was counted at physiological maturity from two randomly selected central rows of one meter square of both treated and untreated plots.

Spike length (cm): It was measured as an average of five randomly taken spikes from one meter square of net plot treatments and untreated plot at physiological maturity.

Number of Kernels per Spike (NPS): It was recorded from five randomly selected spikes per meter square of the treatments plot of treated and untreated plots at harvest and the average length was calculated per spike basis. The Kernels separated from spikes to get the number of kernels per spike.

Grain yield (q ha^{-1}): The yield data that was taken by harvesting and threshing the grain from one meter square (m^{-2}) and converted to quintal per hectare. The grain yield will be adjusted to 12.5% moisture content as:

Grain yield (q ha^{-1}) = yield obtained (q ha^{-1}) x ((100-% Actual Moisture content))/ (100-12.5).

2.5.Data Analysis

Analysis of variance (ANOVA) was done using SAS software (SAS, 2002). Homogeneity of variances was tested using *F*-test as described by Gomez and Gomez (Gomez KA and Gomez AA., 1984). The comparison was made at five per cent level of significance using List Significant differences.

3. Results and Discussion

3.1. Days to heading

The analysis result on days to 50% heading was significantly ($p<0.05$) affected by sowing methods (Table 1). Days to heading were delayed in full ART methods and boarding combined with traditional 'Marasha'. Early days to heading were noted in broadcast method. It could be due to higher competition for growth resource which could enhance vegetative growth. On the other hand, accessibility of ample resources under full ART sowing method pronged growth phases which improved the vegetative growth of wheat crops. These results are in line with the findings of Siddique & Bakht (2005) who investigated that days to tasseling and maize silking were delayed in ridge planting. The influence of sowing methods on days to heading is presented in Fig. 10. The maximum number of days to fifty per cent heading was recorded in full ART, while the lowest was in broadcast sowing method.

3.2. Plant height (cm)

Plant height was differed significantly ($p<0.05$) when farmers utilized different sowing methods. Wheat crops sown using full ART and leveling board combined with traditional 'Maresha' sowing methods produced the tallest crops as compared with broadcasting sowing method. This might be due to the fact that the former provided better soil conditions for nutrient uptake and aeration which lead to maximum production of photo assimilate by reduced lodging. Similar results are also reported on other cereal crops by Belachew & Abera (2010). These researchers found that taller plants were obtained with ridge sowing.

3.3. Days to physiological maturity

The results of analysis of variance revealed that sowing methods had significant ($p<0.001$) effect on days to 90% physiological maturity of wheat (Table 1). Late days to physiological maturity was recorded when crops were sown by full ART and this was on par with leveling board combined with traditional 'Maresha' sowing method applied in this study. However, early days to physiological maturity was recorded when wheat crops sown by broadcasting (Table 1). The earlier maturity observed with broadcasting might be due to the increased plant population per unit area that increased competition between crops for nutrients and light which make varieties stay no longer in vegetative stage. This might have also contributed to the reduction in grain yield, because at higher seed rate heading and maturity hastened as compared to full ART and leveling board combined with traditional '*Maresha*'.

Table 1. Effects of different sowing techniques on phonology and growth parameters of wheat

Treatments	Days to heading (days)	Plant height (cm)	DPM (days)
Full ART+BM (T_1)	72.22a	92.94a	105.39a
Only ART LB + Traditional M. (T_2)	69.53^{ab}	89.25^{ab}	99.96ab
BCSM (T_3)	66.75^{b}	86.69^{b}	95.66b
LSD (0.05)	4.01	4.16	8.41

Note: within dependent variables, means with different subscripts differ significantly at 5% level of significance; DPM = days to physiological maturity; T_1= full Alemayehu's Technology + *Bareken Maresha*; T_2= only levelling board plus Traditional *Maresha*; T_3 = broadcasting sowing method (BCSM)

3.4.Number of Effective tillers (m^{-2})

Number of effective tiller was non-significantly influenced by different sowing methods. The maximum productive tillers per meter square was recorded when plots were seeded with full ART and followed by board plus traditional *Maresha*.˙ However, minimum productive tillers per meter square were recorded from broadcasting (Table 2). The higher productive tillers in full ART sowing methods might have resulted from loose soil conduction that facilitated the availability of adequate nutrient and aeration created by full Art components

3.5.Spike length (cm)

The result of the study showed highly significant ($p<0.001$) effect on spike length (Table 2). However, shorter spike length was recorded when crops were sown by broad plus traditional *Maresha*. Significantly longer spike length (about 18.61% and 9.76%) were observed by full ART sowing methods and broad plus traditional *Maresha* treatment, respectively over broadcasting treatment. On average the different treatments produced 7.00 cm spike length. This might be due to the major role played by component of full ART in creating suitable environment for availability of nutrients and air that helped the crop for cell division and elongation. The result is supported by the work of Fayera *et al*. (2014) who reported that the spike length of wheat significantly increased as a result of applied Zn and B blend with macronutrient.

3.6 Number of seeds per spike

Results in Table 2 indicated that different sowing methods had a significant effect on number of seeds per spike. Full ART produced the highest number of grains spike^{-1} (Table 2), compared with those recorded when wheat was sown under broad plus traditional *Maresha* and broadcasting treatments. The increase may be due to the available nutrient and loose soil for aeration during crop life that helped rapid growth and formation of good canopy assisted the process of good photosynthesis. The higher uptake of nutrients resulted into enhanced number of grains per spike due to its involvement in grain formation and development.

Table 2. Effects of different sowing techniques on yield components of wheat

Treatments	**NET (m^{-2})**	**SL (cm)**	**NSPS**
B M + full ART set	249.84	72.22a	92.94a
Only ART LB + TM	235.71	69.53^{ab}	89.25^{ab}
Traditional + BCSM	231.61	66.75^{b}	86.69^{b}
LSD (0.05)	NS	4.01	4.16
CV (%)	17.08	6.25	4.22

Note: within dependent variables, means with different subscripts differ significantly ($P < .05$); NET = number of effective tillers per square meter; SL = spike length; NSPS = number of seeds per spike.

3.7. Yield per hectare (kg ha^{-1})

The ultimate goal in crop production is to get maximum economic yield, which is a complex function of individual yield components in response to the genetic potential of the cultivars and inputs used. The use of full ART sowing method showed highly significant ($p<0.01$) effect on grain yield (Table 3). The maximum grain yield of wheat was obtained from sowing seeds by using full ART compared to both board plus '*bereken Maresha'* and broadcasting sowing methods. This might be due to conducive soil conditions created by components of Full ART particularly inter cultivator which loosen the soil physical structure that enhanced nutrient availability and aeration of the crop roots. This could have led to better growth and development of optimum assimilates. This leads to optimal partitioning of photo assimilates to the harvested part of the plant as the yield of crops depends on the translocation of assimilates from vegetative parts (leaves). The lowest grain yield of bread wheat in this study was recorded from a plot sown by broadcasting method.

The full ART set + *Bereken Maresha* and only levelling board combined with traditional *Maresha* enhanced yield performance of wheat crop (25.37% and 18.34%), respectively as compared to broadcasting seeding method as illustrated in (Table 3). This might be due to conducive environment created by sowing methods used for seeding wheat crop. Furthermore, the difference in the grain yield of wheat crop might be due to the difference in their yield components like spike length, kernels per spike, no of effective tillers and the like.

Table 3. Effects of different sowing techniques on yield of wheat.

Treatments	**Yield (q ha^{-1})**
B M + full ART set (T_1)	60.86a
Only ART LB + TM (T_2)	55.62b
Traditional + BCSM (T_3)	45.42c
LSD (0.05)	5.09
CV (%)	11.52

Note: within dependent variables, means with different subscripts differ significantly

4. Conclusions and Recommendations

4.1. Conclusions

Based on the finding of this study the following points were concluded. Different sowing methods tested in this trial have significance variations for tested growth and yield parameters across eight districts of Arsi zone. According to this finding the utilization of full ART set together with *Bereken Maresha* for sowing wheat crops recorded significantly the highest days to heading, plant height and days to physiological maturity. Furthermore, it also significantly influenced number effective tillers, spike length and number of seeds per spike that finally led to the highest wheat production across eight districts of Arsi zone as shown in material and methods as compared to the remaining two treatments (T2 and T3). Therefore, for high yield output full ART set together with *Bereken Maresha* sowing methods followed by only ART levelling board plus Traditional *Maresha* and broadcasting methods should be chosen

4.2. Recommendations

Based on above conclusions the following points were forwarded. For most observed growth parameters in this study, all parameters had significant variation in the three sowing methods. According to this finding height of the plant was affected by sowing methods. Therefore, full ART set together with Bareken Maresha should be recommended sowing methods to influence the growh parameters in wheat production. The numbers of tillers under the above sowing methods were significant. Therefore, for high yield output full ART set together with Bereken Maresha sowing methods followed by only ART leveling board plus Traditional Maresha and broadcasting methods should be chosen.

On the other hand, ART takes much time to assemble and operate the different ART component, which is changing over time from one activity to the other, which is from harrowing to ridging, from ridging to leveling, from leveling to cultivating. Therefore, it would be better if all parts of ART fixed on a single base to ease of operating of these components. Undeniably, most of the non-user farmers are willing and have high demand to adopt ART and its components if they didn't have financial constraints to adopt the technology. Thus, we recommend the price of the technology should be reconsidered or the payments should be facilitated by the government and non-governmental organizations e.g. by establishing institution as a small and micro-enterprise or cooperatives to address much number of smallholder farmers.

However, placing wheat seed in-row alone might not be the only factor for yield advantage over broadcast planting method. Other agronomic practices such as row and seed spacing, seed and fertilizer rates, early hand weeding and other agronomic practices need to be considered for increased wheat yield in the study area. Therefore, this study recommends carrying out further additional agronomic research over location and time in order to raise wheat yield for the successful promotion and adoption.

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