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Research Article

Participatory Demonstration of Durum Wheat Production Blending Vertisols Management Technologies in Lume District, East Shewa, Ethiopia

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Abstract

Durum wheat production on Vertisols is constrained by waterlogging, where excessive soil moisture limits nutrient availability, resulting in lower yields and higher input demand. Aybar broad bed maker (BBM) was recommended to make broad beds and furrows (BBF) and drain the excess water although it is not widely adopted by farmers. Therefore, this demonstration activity was conducted to create awareness about the importance of BBF along with the recommended fertilizer rates in Lume district during the 2021 and 2022 main cropping seasons. Nine target farmers were purposefully selected based on the ground that their farms are waterlogged Vertisols. Aybar BBM to make the BBF with an 80 cm bed and 20 cm furrow width, while recommended fertilizers at a rate of 92 kg ha^{-1} nitrogen (N) and 10 kg ha^{-1} phosphorous (P) were used. The yield data and farmers' perception were analyzed using t-test, descriptive statistics, and narration, while partial budget analysis was conducted to examine the economic feasibility of the technologies. Results showed that growing durum wheat on BBF by applying the recommended N and P rates resulted in significantly higher grain yield (3474 kg ha^{-1}) *with a 65.4% yield advantage* compared to ridge and furrow (RF) (2100 kg ha^{-1}) with the blanket fertilizer rates. The partial budget analysis revealed that land preparation using Aybar BBM, alongside the recommended fertilizer rates, brought a net benefit of 48,563 ETB ha^{-1} over the farmers' practice. Likewise, the marginal rate of return for changing from the local plow to Aybar BBM is 901.7%. The farmers also witnessed that the Aybar BBM even takes less plowing time and energy, and they want to continue to use it. *In light of these results, the study concludes that the use of Aybar BBM and recommended N and P rates, as a production package on waterlogged Vertisols, is profitable for farmers and recommends promoting and scaling up these technologies in the study area and other waterlogged Vertisols regions of the country.*

Keywords

Aybar BBM, Farmers' Perception, Fertilizer Rate, Water Logging

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1. Introduction

Vertisols are potential areas for durum wheat production. However, wheat production on Vertisols is mainly constrained by severe waterlogging due to the hydro-physical properties of the soil and the intense summer rainfall [1]. This also results in a lower content of soil nutrients and a poor response of the crop to fertilizer applications [2]. Waterlogging is one of the most common abiotic stress factors that affect crops and is responsible for losses representing 15-20% of the total area sown to wheat each year worldwide [3]. Studies revealed significant reductions due to waterlogging occurred for yield, some yield components, proline and protein contents, as well as chlorophyll a and chlorophyll b in wheat [4-6].

As part of the solution, by making an improvement to the existing traditional RF (ridge and furrow) drainage system, the BBF (broad beds and furrows) made by an animal-drawn plow, the broad-bed maker (BBM), was introduced into Ethiopia by the International Livestock Center for Africa [7, 8, 1]. Since then, various studies on the technology have been conducted, and it has been recommended to grow wheat on BBF in terms of crop yield and financial benefits for waterlogged Vertisols areas [1, 2, 9]. Improving drainage through BBF might enable early sowing, increase the growth period without drought stress, and therefore enhance seed yield [10]. In their study, Teklu *et al*. [1] recommended the adoption of BBF for lentils, reduced tillage (RT) with BBF for wheat, and RT for tef to improve crop yield and generate financial benefits. They suggested that the improvement in surface drainage and yield increase were spectacular during the excessive rainy years. In line with this, Abayneh [9] provided evidence that using BBF resulted in a 22% yield advantage over traditional Vertisols technology. Moreover, the use of BBF has been reported to increase the yield of durum wheat by improving the nitrogen use efficiency of the crop [11, 7].

Vertisols in the highlands of Ethiopia are proved deficient in soil N and P [13], where the heavy summer rainfall adding to the poor drainage in Vertisols leads to the loss of nitrogen from the soil due to leaching and denitrification. On the other hand, owing to the fixation of P with the dominant Ca^{2+} ion in the exchange site, the deficiency of available P in the Vertisols of the country has ample evidence [14, 13]. In an effort to close this gap, field experiments were conducted, and 92 kg ha^{-1} N and 10 kg ha^{-1} P were recommended as optimal rates for durum wheat grown on Vertisols.

Even with its significant advantage, neither the recommended ideal N and P fertilizer amounts were introduced nor is BBF technology practiced among farmers. Though farmers have acknowledged some of the efforts, adoption is very slow, and disseminating Vertisols technologies like Aybar BBM among farmers has been a long-standing challenge [15]. The reason for the low uptake and impact of innovations may be that either the implementing actors have not sufficiently understood the technology or have inadequate engagement with the scaling process. Therefore, this study was conducted to demonstrate and promote the BBF technology using the recently modified Aybar BBM along with the recommended N and P fertilizer rates for durum wheat production in the Vertisols areas of Lume district of Ethiopia.

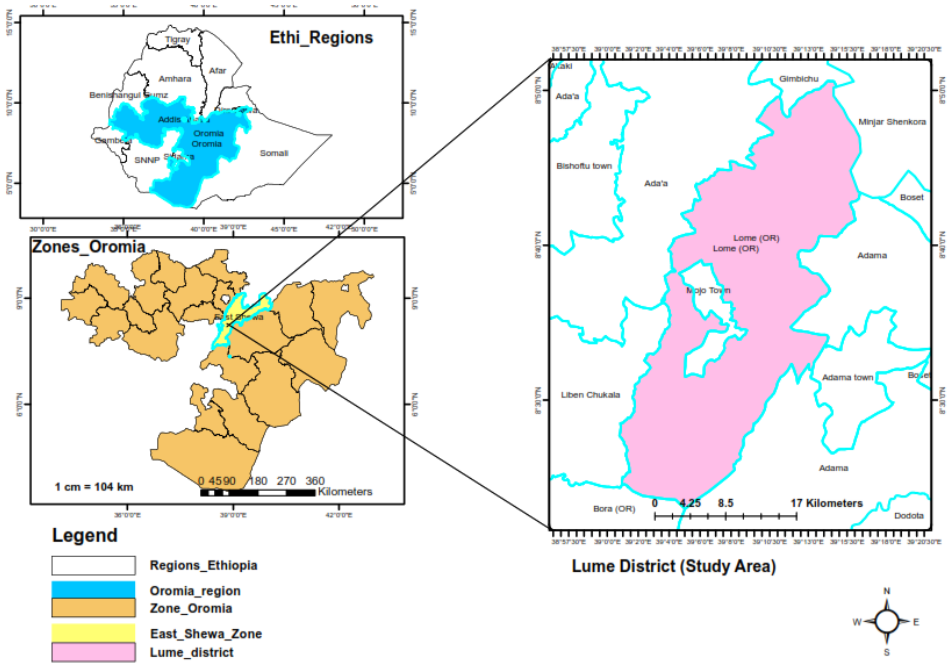

Figure 1. *Location map of the study area.*

2. Materials and Methods

2.1. Description of the Study Area

The demonstration was conducted in Lume district, located in the central highlands of Ethiopia, for two consecutive cropping seasons, from 2021 to 2022. It is geographically located between 8°34′59.99″ N and 39°09′60″ E at an altitude ranging from 1,500 to 2,300 meters above sea level, which is located 70 km southeast of Addis Ababa. The district has a sub-humid climate and receives a mean annual rainfall of 1,065 mm. The mean monthly temperature of the area ranges from 22 ℃ to 34 ℃. The major soil type of the district is Vertisol [16], with a clayey soil texture.

2.2. Implementation Design

2.2.1. Input Supply and Field Management

The technologies that are demonstrated were a previously recommended drainage method, BBF using Aybar BBM, and the recommended fertilizer rates. Broad bed and furrow is a surface drainage method constructed by the Aybar BBM, which is an oxen-drawn implement modified for the construction of a series of raised beds and furrows. The implement makes BBF with an effective bed width of 80 cm and 20 cm furrows to enable the crop to grow on the bed and drain the excess water through the furrows of 15 cm depth [17]. Along with the BBF, 92 kg N ha^{-1} and 10 kg P ha^{-1} were used for the demonstration, which were previously recommended for the production of durum wheat on Vertisols by the Debrezeit Agricultural Research Center. For comparison, the farmers' practices of land preparation, RF, and fertilizer rates of 107 kg ha^{-1} N and 33.2 kg ha^{-1} P were taken into account. Ridge and furrow are parallel, narrow structures of about 20 cm high and 30 cm wide that are constructed with the traditional plow. This makes the crops grow on the ridges and allow the excess water to drain through the furrows. The recommended amount of seed of the Utuba variety was delivered to the host farmers free of charge. The participant farmers managed their fields as per the recommendations for all demonstration plots with the close supervision of researchers and district agricultural development agents, while a continuous follow-up was undertaken in the course of the implementation of the activity.

2.2.2. Site and Farmers Selection

This study was conducted in two *Kebeles* of Lume district, namely, Ejere-welkite and Tulurae. A total of nine sites that have problems of waterlogging were selected. Nine target farmers from the two *kebeles* were selected based on their willingness to allocate the required plots of land (0.25 ha per head) for the demonstration activity as well as their interest in participating in the demonstration activity. Teams of researchers, in collaboration with district agricultural development office experts and *kebele*-based agricultural extension agents, selected the farmers jointly.

2.2.3. Training

Prior to the implementation of the technology demonstration, both theoretical and practical training was given to different stakeholders on the methods to use the Aybar BBM to make the BBF, the benefits of BBF, fertilizer application, and the overall management of durum wheat grown on Vertisols. Moreover, farmers were trained practically on farm on how to use the Aybar BBM to make the BBFs during the planting of durum wheat. Thus, a total of 28 farmers, 11 development agents, and 2 agricultural experts were involved in the training. In general, the main aims of the training were to validate the results and create awareness of the importance of BBF, along with the recommended fertilizers and crop management.

2.2.4. Field Day and Experience Sharing Events

Field days and field visits play a crucial role in the demonstration of agricultural technology. They provide a platform for knowledge exchange and collaboration among different stakeholders, including researchers, farmers, and field experts [18]. These events facilitate the introduction and adaptation of new technologies among farmers and inspire others to adopt similar practices by demonstrating the successful implementation of new technologies [19].

Table 1. *Summary of field day participants on the demonstration of broad beds and furrows for durum wheat production.*

No.	Location (kebele)	Farmers		Agricultural development agents		Agricultural experts		Researchers	
		Male	Female	Male	Female	Male	Female	Male	Female
1	Ejere-welkite	42	7	4	1	3	0	11	6
2	Tulurae	38	5	6	1	3	0	9	6
Total		80	12	10	2	6	0	20	12

Source: (Own data, 2021/22)

Thus, field days were organized at maturity stages to evaluate the performance of the crop and create awareness about the availability and importance of the demonstrated technology for different end users. Hence, 142 participants (116 males and 26 females) attended the event, including farmers, development agents, agricultural experts, and researchers (Table 1). Hence, 142 participants (116 males and 26 females) attended the event, including farmers, development agents, agricultural experts, and researchers (Table 1). In addition, participatory technology evaluation was carried out, and the performance of the demonstrated technology was evaluated by a group of farmers against their own selection criteria, such as ease of operation and maintenance, effectiveness in reducing labor and cost, and applicability in different areas, including yield advantage.

Figure 2. *Performance and demonstration of durum wheat grown on BBF in Lume district in 2022.*

2.3. Data Collection and Method of Analysis

For this activity, both quantitative and qualitative types of data were employed. The quantitative types of data, such as the grain yield and the costs incurred and income gained, were collected through structured checklists, while the qualitative types of data, such as the preferences and feedback of the farmers, were collected through focus group discussions (FGD). Descriptive statistical analysis, such as minimum, maximum, mean, and standard deviation was used to describe the yield performance of the crop in response to the technology demonstrated. Further, the independent two-sample t-test was conducted to determine if there was a significant difference between the mean grain yield obtained from the recommended and famers' practices at the 5% level of significance using the R-software version 4.1.3 [20]. The partial budget analysis was also performed to evaluate the economic advantage of the technologies implemented using the procedures of CIMMYT [21]. On the other hand, qualitative types of data, such as feedback and perceptions of farmers towards the technology were analyzed by narration.

3. Results and Discussions

3.1. Yield Performance

To evaluate the performance of the crop, data on grain yield were collected from nine farmers' fields. The t-test results show that there was a significant difference ($P < 0.001$) between the yield of durum wheat grown on BBF made by the Aybar BBM and the one grown on RF made by the local plow (Table 3). The mean grain yield of durum wheat grown on BBF made by Aybar BBM and applying the recommended N and P rates was found to be superior (3474 kg ha^{-1}) over the yield obtained from the RF, which is constructed by the local plow (2100 kg ha^{-1}) with the fertilizer rates used by farmers (Table 2). Accordingly, using the Aybar BBM for the production of durum wheat resulted in a 65.43% yield advantage over the local plow (Table 2).

Table 2. *Grain yield performance of durum wheat under Aybar BBF technology and local plow.*

Management Practice	Yield (kg ha-1)			Std. Deviation	Yield advantage of Aybar BBM over the local plow (%)
	Minimum	Maximum	Mean		
BBF made by Aybar BBM	25.20	47.60	34.74	8.05	65.43
RF made by local plow	15.00	27.00	21.00	4.12	

Source: (Own field data, 2021/22)

$$\text{Yield advantage}(\%) = \frac{\text{Yield of Aybar BBM} - \text{Yield of local plow}}{\text{Yield of local plow}} * 100$$

The results indicate that the use of Aybar BBM and recommended fertilizer rates is effective for durum wheat production on waterlogged Vertisols. The findings of this study are in agreement with previous studies that have shown the potential of BBF in alleviating the problem of waterlogging and improving crop productivity on Vertisols [1, 22]. Similarly, Tadesse and Birhanu's [12] investigation showed that draining off the excess soil water from the rhizosphere is the primary strategy for enhancing nutrient uptake in Vertisols.

Table 3. *Results of two Sample independent t-test.*

Practice	T	df	P-value	Mean difference (kg ha^{-1})	95% confidence interval of the difference	
BBF made by Aybar BBM	4.56	11.93	0.00067	34.74	Lower	Upper
RF made by local plow				21.00	7.17	20.32

Source: (Own field data, 2021/22)

3.2. Partial Budget Analysis

The partial budget analysis of the demonstrated technology revealed that growing durum wheat on BBF made by Aybar BBM resulted in a higher net benefit of 11,5438.20 Ethiopian birr (ETB) than the RF made by the local plow, which is 66,874 ETB (Table 4). Further, the economic analysis showed that using the Aybar BBM brings a marginal rate of return (MRR) of 901.7%, implying that for every ETB invested in using the Aybar BBM, the producer would collect 90.17 ETB after recovering his investment to produce the crop. The partial budget analysis also showed that using the recommended optimum fertilizer rate contributed to the higher profit over using the local plow, along with the higher amount of fertilizer used by farmers.

Table 4. *Partial budget analyses of the demonstrated technologies.*

	Local plow	Aybar BBM
Average yield (kg ha^{-1})	2100.00	3474.00
Adjusted yield (kg ha^{-1})	2098.55	3126.60
Gross field benefit (ETB ha^{-1})	88139.10	131317.00
Cost of NPS (ETB ha^{-1})	5840.00	1766.60
Cost of Urea (ETB ha^{-1})	4137.75	4771.60
Cost of seed (ETB ha^{-1})	10720.00	9000.00
Cost of Labor for seed covering (ETB ha^{-1})	531.20	265.60
Cost of the Implement (ETB ha^{-1})	35.60	75.00
Total costs that vary (ETB ha^{-1})	21264.55	15878.80
Net benefit (ETB ha^{-1})	66874.55	115438.20
Marginal rate of return (%)	901.7	

Source: (Own field data, 2021/22)

This this result is evidence that using BBF enhances the efficiency of the applied fertilizer, which was explained by the work of Ali [11], who reported the contribution of BBF to nitrogen use efficiency. Likewise, in the study of Tadesse and Birhanu [12], draining off the surplus water in Vertisols was proven to boost nutrient uptake, leading to fertilizer use efficiency and cost-effective crop production. Therefore, the current study showed that the use of Aybar BBM to make BBF along with the recommended N and P rates as production packages to grow durum wheat are profitable for farmers, particularly in areas with waterlogging problems.

3.3. Feedback and Perception of Farmers

During the demonstration conducted at Ejere–Welkite *Kebele*, farmers mentioned that they were unsuccessful in producing wheat on their farm previously due to the water logging problem in the area. However, using the Aybar BBM helped them a lot to drain the water and grow the crop on BBF with good performance. Similarly, farmers who participated in Tulurae Kebele perceived that crops grown on BBF perform better compared to those grown on ridges and furrows created by local plows. They also found that the demonstrated fertilizer rate was optimal and cost-effective compared to the amount they previously used. Additionally, participant farmers witnessed that at the time of planting, using the Aybar

BBM was more time and energy-efficient than using the local plow, where they found the Aybar BBM taking six to eight hours less than the local plow, depending on the soil's workability. Farmers also noticed that growing wheat on BBF makes it easier to walk on the farm and implement different crop management practices such as fertilizer application (top dressing of urea fertilizer), weeding, and pesticide application. They have also shown their interest to use the modified farm implement and the recommended fertilizer rate for the production of wheat in the future. Therefore, this positive feedback from farmers on both Aybar BBM and the recommended fertilizer rates has implications for further scaling up of the practices in other Vertisols areas.

4. Conclusions and Recommendations

Broad beds and furrows made by the modified Aybar BBM with the recommended fertilizer rates for durum wheat were demonstrated in the Vertisols areas of Lume district. The demonstrated drainage method, BBF prepared by Aybar BBM, brought a yield advantage over the RF made by the local plow. This was also supported by the economic benefit of using the recommended land preparation method and fertilizer amount. A wider demand-pull was created by reaching a large number of farmers through training, on-farm demonstrations, and field day events. The participated stakeholders had positive feedback and perceptions about the demonstrated technologies, and farmers showed their interest in using them. In general, the demonstrated technologies of Aybar BBM and the recommended N and P rates are profitable and effective in the production of durum wheat on waterlogged Vertisols. The promotion of these technologies will help to improve the livelihoods of farmers by increasing their income and food security. Therefore, it is recommended to promote and scale up the Aybar BBM technology and the recommended fertilizer rates in waterlogged Vertisols areas of the country by involving different stakeholders such as, governmental and non-governmental organizations, the private sector, and other stakeholders.

Abbreviations

BBM	Broad Bed Maker
BBF	Broad Beds and Furrows
ETB	Ethiopian Birr
RF	Reduced Tillage
FGD	Focus Group Discussion
CIMMYT	International Maize and Wheat Research Center
MRR	Marginal Rate of Return

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Author Contributions

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Assefa Gonfa: Data curation, Investigation, Methodology, Supervision, Validation, Visualization, Writing – review & editing

Sosena Amsalu: Data curation, Investigation, Methodology, Supervision, Validation, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Teklu Erkossa, Stahr K., and Gaiser T. 2006. Soil tillage and crop productivity on Vertisols in Ethiopian highlands. *Soil and Tillage Research* 85(1-2): 200–211. https://doi.org/10.1016/j.still.2005.01.009

[2] Amare Aleminew Wubie. 2015. Review on Vertisol Management for the Improvement of Crop Productivity in Ethiopia. *Journal of Biology, Agriculture and Healthcare*, 5(12): 92-103. https://www.iiste.org/Journals/index.php/JBAH/article/view/23271

[3] Setter, T. L., and Waters, I. 2003. Review of prospects for germplasm improvement for waterlogging tolerance in wheat, barley and oats. *Plant and Soil*, 253(1): 1-34. https://doi.org/10.1023/a:1024573305997

[4] Olgun, Murat, Metin Kumlay, A., Cemal Adiguzel, Mesut and Caglar, Abdullah. 2008. The effect of waterlogging in wheat (T. aestivum L.). *Acta Agriculturae Scandinavica, Section B - Plant Soil Science*, 58(3): 193-198. https://doi.org/10.1080/09064710701794024

[5] Hasanuzzaman, M.; Mahmud, J. A.; Nahar, K.; Anne, T. I.; Inafuku, M.; Oku, H.; Fujita, M. 2017. Responses, adaptation, and ROS metabolism in plants exposed to waterlogging stress. *Reactive Oxygen Species and Antioxidant Systems in Plants: Role and Regulation under Abiotic Stress*. pp. 257–281. https://doi.org/10.1007/978-981-10-5254-5_10

[6] Bali, A. S.; Sidhu, G. P. S. 2019. Abiotic stress-induced oxidative stress in wheat. *Wheat Production in Changing Environments*. pp. 225–239. https://doi.org/10.1007/978-981-13-6883-7_10

[7] Abiye Astatke and Jabbar, M. A. 2001. Low-cost animal-drawn implements for Vertisol management and strategies for land-use intensification. In *The sustainable management of Vertisols*. Wallingford UK: CABI. pp. 189-201. https://doi.org/10.1079/9780851994505.0189

[8] Tekalign Mamo and Mohamed-Saleem MA. 2001. Soil and water research in Ethiopia. In: Dubale P, Dibabe A, Zeleke A, Ayele G, Kirub A, editors. Advances in Vertisols management in the Ethiopian highlands. *Proceedings of the International Symposium on Vertisol Managegment*, 28 November–1 December 2000, Addis Ababa, Ethiopia. Debre Zeit (Ethiopia): EARO. pp. 13–18.

[9] Abayneh Wubetu. 2017. A review on Vertisol management, challenges and future potential for food self-sufficiency in Ethiopia. *Journal of Biology, Agriculture and Healthcare*, *7*(17): 115-127. https://www.iiste.org/journals/index.php/jbah/article/view/38852

[10] Getachew Agegnehu and Woldeyesus Sinebo. 2012. Drainage, sowing date and variety effects on chickpea grown on a Vertisol in Ethiopia, Archives of Agronomy and Soil science, 58: 1, 101-113. https://doi.org/10.1080/03650340.2010.503958

[11] Ali Yimer. 1992. Nitrogen transformation in some Ethiopian highland Vertisols. PhD thesis, University College of Wales, Aberystwth, UK. pp 174.

[12] Tadesse Debele and Birhanu Iticha. 2017. Effects of drain depth of Vertisols, nitrogen source and time of application on nutrient uptake by maize (Zea mays L.) in western Ethiopia. *International journal of Agricultural Research, Innovation and Technology.* 7(1): 1-7. https://doi.org/10.3329/ijarit.v7i1.33314

[13] Hillette Hailu, Tekalign Mamo, Riikka Keskinen, Erik Karltun, Heluf Gebrekidan, and Taye Bekele. 2015. Soil fertility status and wheat nutrient content in Vertisol cropping systems of central highlands of Ethiopia. *Agriculture & Food Security*, 4: 1-10. https://doi.org/10.1186/s40066-015-0038-0

[14] Tekalign Mamo, Richter C., Heiligtag B. 2002. Phosphorus availability studies on ten Ethiopian Vertisols. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, 103(2): 177-183 https://www.jarts.info/index.php/jarts/article/view/12

[15] Gezahegn Ayele, Jabbar, M. A. and Elias Zerfu. 2001. Diffusion and adoption of Verisols technology package in highland Ethiopia. pp: 263-272.

[16] Addis Tiruneh, Teklu Tesfaye, Mwangi W, Verkuijl H. 2001. Gender Differentials in Agricultural Production and Decision-Making among Smallholders in Ada, Lume, and Gimbichu Woredas of the Central Highlands of Ethiopia. Mexico, D. F.: International Maize and Wheat Improvement Center (CIMMYT) and Ethiopian Agricultural Research Organization (EARO). https://repository.cimmyt.org/server/api/core/bitstreams/fdb3f6bf-4673-44ed-9142-ce0d291c610f/content

[17] Jutzi, S. and Mesfin Abebe. 1987. Improved agricultural utilization of Vertisols in the Ethiopian highlands- an inter-institutional approach: Proceedings of the first regional seminar on management of Vertisols under semi-arid conditions held in Nairobi, Kenya 1-6 Dec. 1986. pp. 173-183. https://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers15-08/010065123.pdf#page=183

[18] Belyaev, V. I., Silantyeva, M. M., Meinel, T., Grunwald, L. C., Belyaev, D. V., Kozhanov, N. A., Sokolova, L. V. 2020. Field Days for Technology Transfer and Knowledge Exchange of Dealers and Farmers. *KULUNDA: Climate Smart Agriculture: South Siberian Agro-steppe as Pioneering Region for Sustainable Land Use*, pp. 493-500. https://doi.org/10.1007/978-3-030-15927-6_37

[19] Emerick, K., and Dar, M. H. 2021. Farmer Field Days and Demonstrator Selection for Increasing Technology Adoption. *Review of Economics and Statistics*, *103*(4): 680–693. https://doi.org/10.1162/rest_a_00917

[20] R Core Team. 2022. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

[21] CIMMYT Economics Program, International Maize and Wheat Improvement Center. 1988. From agronomic data to farmer recommendations: an economics-training manual. CIMMYT, Mexico. http://repository.cimmyt.org:8080/xmlui/bitstream/handle/10883/859/25152.pdf

[22] Tadesse Debele and Haile Deressa. 2016. Integrated Management of Vertisols for Crop Production in Ethiopia: A Review. *Journal of Biology, Agriculture and Healthcare*. Journal of Biology, Agriculture and Healthcare. Addis Ababa, Ethiopia, 6(24): 2224-3208. https://www.iiste.org/Journals/index.php/JBAH/article/view/34548