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Review on: Impact of Seed Rates and Method of Sowing on Yield and Yield Related Traits of Teff [*Eragrostis teff* (Zucc.) Trotter]

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Abstract

Teff [Eragrostis teff (Zucc.) Trotter] is native to Ethiopia. Self pollinated warm season annual grass with the advantage of C_4 photosynthetic pathway and tetraploid 2n=40 plant/crop. It can grow in diverse agro-ecology zones starting from to 2800 m.a.s.l worldwide. Countries like USA, Canada, Australia, Netherlands, South Africa and Kenya produce teff for different purposes such as forage crop, thickener for soups, stews and gravies. Even if Teff grows in the indicated world countries, the largest production of Teff in the world is from Ethiopia where annually, above 6,562,325 farmers grow Teff on above 2.87 million hectares, which is about 22.95% of the total cultivated land in the country. From the production of the total grain crops teff contributed 16.1 % (4,471,378.7 tons) in the country. This is due to the farmer's indigenous farming practice and varietal selection. Teff can be considered as alternative cereal crop for growers and also beneficial as an additional gluten free source and have higher fibour content for people suffering from coeliac disease and diabetics in the world respectively. Despite of these facts; the productivity of teff is still lower due to spatial heterogeneity of agronomic practices, climatic conditions and other factors. Teff ranks the lowest yield compared with other cereals grown in the world particularly in Ethiopia. The cause for the lower yield of teff is lodging, method of sowing, use of suboptimum seed rate and fertilizer application. Meantime the combined effect of those factors result up to 22% reduction in grain yield. This review demonstrated that higher performance in grain yield, tillering, panicle length and vegetative biomass signaling great yield potential due to Row sowing than broadcast and using of optimum seed rate could be recommended for maximum teff grain and straw yield. Moreover field based research on agronomic practices like method of sowing and seed rate should be preceded.

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Keywords

Method of sowing, Seed rate, Row sowing and Broadcast sowing

Introduction

Background of the review

Teff [*Eragrostis teff* (Zucc.) Trotter] is native C_4 self-pollinated, chasmogamous annual warm season grass that is used throughout Ethiopia as grain crop for human consumption and as forage for livestock (Abraham *et al.*, 2018). According to Vavilov (1951) Ethiopia is the geographical centre of origin and diversity. The word teff is said to have most likely originated from the Amharic word "*tefa*" which means lost because of its small grain size which is difficult to find once it is dropped while other evidence full investigations state that it was derived from Arabic word tahf, a name given to a similar wild

plant used by Seimites of south Arabia during the time of food insecurity (Abraham *et al.,* 2018).

Countries like USA, Canada, Australia, Netherlands, South Africa and Kenya produce teff for different purposes such as forage crop, thickener for soups, stews and gravies .Tef seeds are Sown on the surface of the soil and left uncovered or sometimes covered very lightly by pulling woody tree branches over the field by oxen (Zewdu, 2008). Even if Teff grows USA, Canada, Australia, Netherlands, South Africa and Kenya, the largest production of Tef in the world is from Ethiopia where annually, above 6,562,325 farmers grow Tef on above 2.87 million hectares, which is about 22.95% of the total cultivated land in the country. From the production of the total grain crops teff contributed 16.1 % (4,471,378.7 tons) in the country. This is due to the farmer's indigenous farming practice and varietal selection (Teshager *et al.,* 2016).

Ethiopia, occupying about 22.6% of the cultivated land from the total area of cereals cultivated 86.06% annually (Dereje *et al.,* 2018). Although area coverage for teff continues to increase; the growth in production and productivity has been driven more by yield increases over time than area increases. This increment is due to a number of factors including relatively high market prices of teff grain and straw. In addition; teff is versatile; as it grows in a wide variety of agro-climatic conditions; including elevations from sea level to 2800 meters above sea level under a similarly wide variety of moisture; temperature; and soil conditions. The cultivated area for teff and other cereal crops has increased proportionally over time (Fikadu, 2019). Similarly Sintayehu and Getachew, 2011 added that, Teff performs well above any other major crops grown under unfavorable circumstances such as low moisture conditions and is often considered as a rescue crop in strategic seasons when early planted crops such as maize suffer from moisture stress. Moreover, its ability to grow in waterlogged areas tolerating anaerobic conditions better than that of many other cereals, including maize, wheat and sorghum, making it preferred cereal crop among farmers. Teff is a highly adapted to diverse agro-ecological zones including conditions marginal to the production of most of the other crops (Hailu, 2001).

Teff is a highly valued crop, For instance it is used for making injera, which is a staple and popular food in the national diet of Ethiopia (Debebe, 2005). However, when grown as a cereal, farmers highly value its straw as source of animals feed, especially during the dry season. Teff straw, besides being the most appreciated feed for cattle, it is also used to reinforce mud and plaster the walls of tukuls and local grain storage facilities called gottera (Dereje *et al.,* 2018). additionally Fikadu (2019) reported that, the sources of livestock feed in Ethiopia are grazing (61.48%); crop straw (27.71%); hay (6.35%); by-products (0.82%); improved fodder (0.8%) and others (3.47%). This indicates that crop straws are the second most important sources of animal feed in Ethiopia. Teff straw is a cereal crop straw which is accounting about 6.93% of the total quantity of cereal crop straws produced in the country.

In Ethiopia teff production is mainly practiced both in shift and permanent farming systems by natives and settlers farming communities respectively. However, its production and productivity is lower than the potential yields obtained on research stations and on farm verification trials. One of the reasons for the low yield is ineffective sowing methods and seed rate (Abraham *et al.,* 2018). Despite many efforts had been undertaken in recent years, the productivity of the crop is still remains below 1.56 tons perha^{-1}. The major constraint hampering teff productivity is lack of access to proper agronomic practices such as improved sowing method, optimum amount of seed and improved varieties seeds which satisfy the national seed standard. Therefore, in most of the cases farmers in Ethiopia are forced to practice the traditional agronomic practice those just adopted previously and use of seed which was saved from previous harvest (Teshager, 2016). Farmers typically plant teff by broadcasting, scattering teff seed by hand at a high seed rate. Alternative planting methods, such as row planting seeds or transplanting seedlings, in which the seed rate is reduced and more space between plants is given, are seen as being superior to traditional broadcasting (Berhe *et al.*,2011).

Hence, present teff production system is unable to satisfy the consumer's demand, since most Ethiopian farmers practice traditional farming system. Production system is not efficiently supported by modern technology due to research gap in choosing most feasible modern technology (Dereje *et al.,* 2018). According to Bekalu and Tenaw (2015) Teff ranks the lowest yield compared with other cereals grown in the world particularly in Ethiopia. The cause for lower productivity is lodging, method of sowing, use of suboptimum seed rate and fertilizer application. Meantime the combined effect of those factors result up to 22% reduction in grain yield. Therefore reviewing and identifying the research gaps as well as take as the main challenges in teff production and

productivity on the issue of seed rate and sowing methods in particular is very important.

Objective of the review

To review the Impact of Seed Rates and Method of Sowing on Yield and Yield related traits of teff.

Review of Literatures and discussions

Definitions of the terms

Teff: May defined as, self pollinated warm season annual grass with the advantage of C_4 photosynthetic pathway and tetraploid 2*n*=40 plant (Bedane, *et al.*, 2015)

Seed rate: It is defined as the amount of seed of an individual plant species that's needed to achieve an adequate stand (Houck, 2009)

Method of Sowing: May be defined as the way of sowing different plant/crop seeds. There are different methods of sowing such as Broadcasting, Row sowing, Dibbling, Drilling, Seed dropping behind the plough, Transplanting, Hill dropping and Check row planting ((Fikadu, 2019).

Broadcasting: Broadcasting is the process of random scattering of seed on the surface of seedbeds. It can be done manually or mechanically both usually higher seed rate is used in this system (Fikadu, 2019).

Row Sowing: It is defined as dropping of seeds in the furrow behind the plough. This is a slow and laborious method but lower seed rate is used in this system (Fikadu, 2019).

Impact of Seed Rates and Method of Sowing on Yield and Yield Related Traits of Teff

Effect of seed rates

Seed rate is the most important agronomic feature which needs due attention. In Ethiopia, blanket recommendation of about 15-55 kg ha^{-1} of teff seeds are sown under different conditions in different states of the country (Debebe, 2005). According to Dereje *et al.*, (2018) when the plant density exceeds than the optimum level, competition among plants for light above ground and nutrients below ground becomes severe. Consequently, plant growth slows down and the grain yield decreases. There was significant increase in yield components of teff with decreasing seed rate from highest to lowest. On the other hand, the lodging percentage of the crop was increased by increasing the seed rate. It is, necessary to determine the optimum seed rate for determining optimum density of plant population per unit area and obtain higher yield of teff.

Major differences were observed only for the plant height and grain yield of teff as affected by seed rate. Application of 10 kg seed with seed sowing of 25 cm row spacing gave the highest plant height (102.44 cm) and followed by application of 5 kg Seed with seed sowing of 15 cm spacing (100 cm). The lowest plant height was obtained with highest seed rate and no spacing (90.9 cm). Increasing plant height with decreased seed rates. This could mainly be attributed to larger seed rate resulting in higher competition for nutrients while in small seed rate less plant competition for nutrients (Dereje *et al.*, 2018). Similarly Arega and Yemgnushal (2018) Worked on five seed rate levels (5kg/ha, 10kg/ha, 15kg/ha, 20kg/ha and 25kg/ha) in different crop parameters and found that, Days to emergence, Days to heading, Days to maturity and harvest index was not significantly affected by the seed rate in teff production. Seed rate significantly affected plant height, number of tillers, total biomass, straw yield, thousand seed weight and grain yield. In the seed rate of 5 kg ha^{-1} obtained maximum grain yield as compared to other treatments. This might be due to very thin stem growth which can lead to easily lodge by high rain-fall and wind. Plants emerged from the seed rate of 5kg ha^{-1} have vigorous and thick stem which prevents lodging as compared to the higher seed rate, so this also affected the grain yield of teff. On the other hand yield related parameters such as plant height; panicle number per plant, panicle length and biomass are factors which lead to grain yield difference among the treatments. The maximum number of effective tillers was recorded in the seed rate at 5kg ha minimum number of effective tillers was obtained from plots treated with 15kg ha^{-1} and followed by 10kg ha^{-1},20kg ha^{-1}. Furthermore, based on the study conducted by Laekemariam *et al.*, (2012 Seeding rate of 15 kg/ha was recommended for maximum grain yield of teff.

In general, all the yield and yield related traits of teff (biomass yield, grain yield, straw yield and thousand seed weight) were significantly influenced by seed rate. Biomass yield increased significantly with the decreasing seed rate. The highest biomass yield (8.8 tone ha^{-1}) was obtained for plot supplied with seed rate of 5kg ha^{-1},

whereas the lowest biomass yield (6.3 tone ha^{-1}) was obtained from seed rate of 25kg ha^{-1} (Arega and Yemgnushal, 2018). Moreover, seed rate had significant effect on growth and yield of teff. Especially teff sown at 5 kg ha^{-1} gave both maximum biological and economic yield. It had a net benefit of 40750 birr ha^{-1} from grain yield. Use of seed rate 5kg ha^{-1} resulted in the maximum grain yields of the crop. It could be concluded and recommend that cultivating teff at the seed rates of 5kg ha^{-1} is effective in attaining higher grain yield and economic benefit (Arega and Yemgnushal, 2018).

Effect of sowing methods

There are different types of sowing methods of teff in Ethiopia; such as; broadcasting and row sowing. Teff sowing with broadcasting method is considered as a traditional teff sowing practice and it has a number of disadvantages like it need much amount of seed rate; reduces the productivity of the crop due to the cause for plant computation of resources such as soil nutrients and others (Fikadu, 2019). In the same way Bekalu and Tenaw (2015) reported that, the most common way of sowing of teff is by broadcasting the small seed at the rate of 25-30 kg ha^{-1}.This sowing method results in lodging; which is the main cause for low yield of teff due to high plant density and computation.

Berhe (2008) also added that most farmers practice the traditional sowing method of teff, which means by broad casting and it results excess crop density and increases competition among plants for nutrients, water, sunlight and carbon dioxide. Moreover broadcasting method requires additional seed rate compared to row sowing method thus increases cost of production. Furthermore, this sowing method results in lodging; which is the main cause for low yield of teff due to high plant density and to minimize the problem of lodging on teff, low seed rate, row sowing, late sowing, and application of plant growth regulators, appropriate rate and timing of fertilizer application is very important (Berhe 2009). However, broadcast sowing method is the best method for sowing grass and alfalfa crops since those crops are used for fodder production (Zewdu, 2008).

Row sowing of teff is expected to increase teff productivity and it requires small amount of seed rate however in reality; it is labor intensive and requires mechanization issues due to the size of the seed is too small. As a result; farmers exposed only put a relatively small part of their farm plots aside for row sowing due to requiring additional labor and back to the traditional way (teff sowing with broadcasting). The issue of the viability of teff row planting under the current agricultural technology of Ethiopia is controversial. Some studies disproved that teff row planting is not cost effectiveness. In contrast; the cost-benefit analyses showed that the increase in teff yield compensates the cost of the additional labor in the first year of adoption when yields increase by 8% and more. Apart from this hard fact; suitable mechanization for row planting of teff would change the cost-benefit picture significantly and is shown to be an investment with possible high returns (Fikadu, 2019). As in agreement of the above explanation, Row sowing method in teff is reported to have better yielding advantage over broadcast sowing method and it can improve production and productivity of teff rather than broadcasting (Hundera *et al.*, 2001).

Wubante (2017) worked on four different varieties of teff (Etsub, Buseye Quncho, Tsedey) in row sowing and deferent row sowing spacing and found that, the overall yield performance of the crop was good at 20 cm inter-row spacing in all of the varieties especially Etsub variety gave relatively better yield and further widening, the inter-row spacing above 25cm, failed to increase yield in all varieties except local variety Buseye, Even if there were no significance mean difference between the row spacing of 20 and 25cm for Etsub and between the row spacing of 20, 25 and 30 cm for Buseye, Quncho and Tsedey varieties, it may be tentatively concluded that a combination of 20 cm row spacing with Estub, 25 cm row spacing with Quncho and Tsedey and 30 cm row spacing with Buseye responded favorably in attaining higher grain yield of teff. Moreover, depending on the agronomic performance and yield of this study variety Etsub at 20 cm row spacing was advantageous. Correspondingly Hussain *et al.,* (2016) reported that row sowing of teff in different spacing have significant effect on panicle length of teff. For instance, Row spacing of teff 30 cm had the longest panicle length (43.6 cm) and it was found in equivalence with the mean panicle length obtained at 20 and 25 cm row spacing.

On the contrary, Bekalu and Tenaw (2015) suggested that, Broadcast sowing method increased panicle length by 11% more than row sowing, because less tillering on broadcasting due to many weed density. This contributes to the growth of panicle length due to minimum competition for nutrients among tillers. Meantime the number of tiller negatively and Sowing method had significantly affected number of panicles per plant. Row sown had 10% more panicle numbers than broadcasted. Because of better root growth in the case of row planting,

this favors the growth and contributes to more panicles per a plant and correlated with panicle length on sowing method had significant effect on grain yield. Row sowing increased grain yield by 24.8% over broadcasted. This might be uneven seed distribution on broadcasting, which results in excess nutritional competition at certain areas and no competition on other areas of the field and thus less grain yield productivity.

Sowing method was significantly affected biomass yield. Row sowed teff yielded 23.8% more biomass than broadcasted. Because of better growth in row sowing, due to easy absorption of photosynthetically active radiations. Row sowing method, had significantly affected the number of tillers. Meanwhile row sowing had 41% more tillers than broadcasting. This is due to difficult situation for weed management results for crop-weed competition and productive tillers by broadcasting became less. Generally Sowing method had significant effect on thousand seed weight. Meantime row sowing had 44.55% more thousand seed weight than broadcasting. These might be because of row sowing, enhances efficiently utilization of applied fertilizer and results for maximum translocation food from source (leaf, stem and branch) to seed. However Sowing method was not significantly affected straw yield (Bekalu and Tenaw (2015).

Correspondingly Berhe *et al.*, (2011) reported that row sowing of teff seed is considered to be superior compared to the traditional broadcasting method because a reduced seed rate decreases competition between the seedlings for water and nutrients. Moreover, the even distribution of the teff seedlings makes weeding easier and less costly. Row sowing has been shown to increase teff yields up to three times average yields and lowers seed costs, making it apparently a good value proposition for teff farmers. Kumela (2016) also added that, Row sowing of teff with 10 cm spacing and application of 80/80 kg of N/P2O 5 ha^{-1} gives higher yield followed by 70/70 kg of N/P with 10 cm row spacing with the same amount of 25 kg ha^{-1} of seed rate resulted in better economical return with maximum grain yield production of teff.

Conclusion and recommendation are as follows

This review can be concluded that, Teff is considered as alternative cereal crop for growers and beneficial as an additional gluten free source and have higher fibour content for people suffering from coeliac and diabetics' disease in the world respectively. Apart from a numerous benefit of teff, it could be super food in the form of Injera worldwide. Despite of these benefit; the productivity of teff is still lower due to spatial heterogeneity of agronomic practices, climatic conditions and other factors. Teff ranks the lowest yield compared with other cereals grown in the world particularly in Ethiopia. The cause for lower productivity is lodging, using of improper sowing method such as broadcast sowing than row sowing method, use of suboptimum seed rate and fertilizer application. Interim the combined effect of those factors result up to 22% reduction in yield and yield related traits such as grain and straw yield. So that identifying this problem and research gap is very important.

Teff is the most important and labor intensive crop in the world. Therefore it requires developing an inclusive strategy at worldwide level both small and large scale production, adoption and forwarding of scientific agronomic practices. Effective and efficient scientific agronomic practices such as row sowing and using of optimum seed rate, might address the most burning exhausting work of teff cultivation. This review demonstrated that higher performance in grain yield, tillering, panicle length and vegetative biomass signaling great yield potential due to Row sowing than broadcast and using of optimum seed rate could be recommended for maximum teff grain and straw yield. Moreover field based research on agronomic practices like method of sowing and seed rate should be preceded.

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