

# Seed Pelleting Technology to Tef [*Eragrostis tef* (Zucc.) Improvements and Its Importance for Agronomic Practice: A Review

Abdisa Mekonnen

Ethiopian Institute of Agricultural Research, Holeta Agricultural Research Center, P.O. Box.  
2003 Addis Ababa, Ethiopia

## Abstract

Tef in Ethiopia, among the cultivated food crops grown it ranks first, with an estimated production area of 3,023,283.5 ha and a mean productivity of 1.75 t ha<sup>-1</sup>. However, despite its importance in Ethiopia, tef yields are low. In the production year 2017-2018, yields were 1.7 t ha<sup>-1</sup> significantly lower than other cereals, such as: maize (3.95 t ha<sup>-1</sup>), sorghum and wheat (both 2.72 t ha<sup>-1</sup>). A knowledge on the use of pelleted seeds in improving the productivity of the tef crop by seed sowing with a minimum time wastage, reduce labor costs, for the use of planting machine to boost the yield of the crop in the country particularly tef grower farmers, investors and other stake holders. From this, to review seed pelleting technology and its importance for agronomic practices and to generate information on seed pelleting for future research direction. The small size of tef seed possess problems during sowing, and indirectly during weeding and threshing. Seed pelleting is the process of enclosing a seed inside a small quantity of inert material just large enough to produce a globular unit of standard size to facilitate planting. Small and irregularly shaped seed can now be treated as larger and round-shaped. Many crop seeds are small and irregular in shape which does not permit the accurate metering by mechanical planting equipments. Pelleting improves the chances of successful germination and seedling establishment under field condition. The pelleting technique increases and homogenizes seed size, but it is essential to determine the physical and physiological characteristics of pelleted seeds. Pellet improvements over the last 10 years include increased O<sub>2</sub> penetration/availability, wider pellet density range, pellet loading, better field visibility. Because of the large increase in volume obtained when seeds are pelleted, pellets have been shown to be effective carriers of plant Protects. Generally application seed pelleting technology for small seed size crops particularly, tef it important for proper planting and maintain planting density of the crop. To this end, research for scientific evident is needed to this technology in the future.

**Keywords:** pelleting technology, Seed pelleting, enclosing a seed

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## INTRODUCTION

Tef [*Eragrostis tef* (Zucc.) Trotter] is the most important cereal crop in the Horn of Africa, especially in Ethiopia, where the last two decades have seen tremendous increases in both the total area devoted to the crop and its production. Tef (*Eragrostis tef* (Zucc.) trotter) is an allotetraploid (2n=4x=40), small cereal grain crop that belongs to the family Poacea, sub-family Eragrostoideae, tribe Eragrostidae and genus *Eragrostis* (Seyfu, 1997). Ethiopia is the center of diversity and origin of tef (Vavilov, 1951). Tef is a staple food supporting some 50 million people in Ethiopia. Currently, the crop is increasingly receiving global attention for its nutritional advantages because it is rich in nutrients and is gluten free. It contains 11% protein, 80% complex carbohydrates, 3% fat (Piccinin, 2002).

Tef has become globally known and various products are available in Europe and North America as health foods especially for persons with gluten intolerance (Saturni *et al.*, 2010). Recently, limited levels of tef cultivation have started in the USA, the Netherlands and Israel. Tef straw is also a valuable source of livestock feed. In South Africa, India, Pakistan, Uganda, Kenya and Mozambique tef is mainly grown as a forage or pasture crop (Kebebew *et al.*, 2011). Interestingly, unlike other cereals, tef is little affected by field and storage pests and diseases (Seyfu, 1997). Among the cultivated food crops grown in Ethiopia, it ranks first with an estimated production area of 3,023,283.50 hectares of land, which is equivalent to 30% of the total area allocated to cereals and a mean productivity of 1.75 t ha<sup>-1</sup> (CSA, 2018). Tef has the genetic potential to yield up to 6 t ha<sup>-1</sup> (Seyfu, 1993). Among the cereals tef is grown by 6,771,977 households, occupying more than three million hectare of land (CSA, 2018). The crop has desirable traits to cope with the changing climate that generate household income, and fulfilling nutritional needs of farmers (Kebebew *et al.*, 2015).

Tef is used in various forms by Ethiopians. Its usage dominantly in the form of injera, unleavened pan cake made of tef flour, which is the mainstay (basis) of Ethiopian diet. It is also consumed in the form of porridge and bread. Tef is gluten-free, rich in phosphorous, copper, aluminum and thiamine and is an excellent source of protein, amino acids and carbohydrates. Tef is higher in calcium, iron and zinc content than corn, wheat, or rice (Baye, 2014).

According to Gamboa and Ekris's, (2008) study on the nutritional and health aspects of tef, it was found the small grain is too small to refine and tef flour includes the bran and germ, which are "the most nutritious parts of any grain". Another health related benefit of tef is the high in fiber content (Bay, 2014). According to Zung, (2004) Stated that is particularly important in dealing with diabetes and assisting with blood sugar control. Its straw is a nutritious and highly preferred feed for livestock compared to the straw of other cereals particularly during dry season. Besides its local use, it is the major cash earning crop for the farming community as market price for both its grain and straw is higher compared to other cereal crops, also it is among export commodity at national level.

However, despite its importance in Ethiopia, tef yields are low. In the production year 2012-2013, yields were 1.4 metric tons ha<sup>-1</sup> significantly lower than other cereals, such as maize (3.1 mt ha<sup>-1</sup>), sorghum and wheat (both 2.1 mt ha<sup>-1</sup>) (CSA 2013). This low tef yield is seemingly explained by the limited knowledge about possible avenues for improving tef productivity, combined with problems inherent to tef botany. Tef research has received limited national and international attention, the latter presumably because of its localized importance in Ethiopia (Takegn *et al.*, 2011). Moreover, tef yields are low because of agronomic constraints that include lodging, low modern input use, sowing methods and high post-harvest losses (Habtegebrial *et al.*, 2007).

Recently it has been argued that the traditional sowing technology is a major constraint to increased tef productivity (Takegn *et al.*, 2011). Farmers typically plant tef by broadcasting, scattering tef 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 (Takegn *et al.*, 2011, Fufa *et al.*, 2011). Experiments on these alternative planting methods in controlled settings have shown large and positive impacts on tef yields (Takegn *et al.*, 2011, Fufa *et al.* 2011). As a consequence, in 2013 the Ethiopian government rolled out a nationwide campaign to promote the use of improved technologies for tef production, including row Planting, aiming to scale up their adoption to almost 2.5 million tef producing farmers. However, the impacts of the widespread promotion campaign of row planting of tef, in particular, on land and labor productivity are unknown. This is mainly due to a lack of reliable and objective farm level data. Moreover, no systematic effort has yet been put into examining farmers' perceptions after they experimented with the new sowing techniques. Seed pelleting technology is an optional for accurate planting especially small seeded crops. The rationale for seed pelleting is to take a seed that is light in density and turn it into a seed with a pellet around it that makes the seed heavier, more uniform and as perfectly round as possible. A planter will be able to plant that seed/pellet in the most accurate and precise way that is feasible (Kubik, 2002).

The most essential phase of precision planting is the singling of seeds for exact placement at a pre-determined depth and spacing in the soil with a uniform coverage and at a reasonable planting speed. Singling is difficult for seeds which are low in density and irregular in shape. To overcome these difficulties seed pelleting is advocated (Bharathi *et al.*, 2003). A knowledge on the use of pelleted seeds in improving the productivity of the tef crop by seed sowing with a minimum time wastage, reduce labor costs, for the use of planting machine to boost the yield of the crop in the country particularly tef grower farmers, investors and other stake holders. Therefore, the objective of this review was to assess seed pelleting technology and its importance for agronomic practices.

## LITRATURE REVIWE

### 2.1. Ecological Distribution of Tef

Tef is primary originated and traditionally harvested grain in Ethiopia, when first domesticated between 4000-1000 BC (Rose, 2011). Tef (*Eragrostis tef* (Zucc.) trotter) is an allotetraploid ( $2n=4x=40$ ), small cereal grain crop that belongs to the family *Poacea*, sub-family *Eragrostoideae*, tribe *Eragrostidae* and genus *Eragrostis* (Ketema, 1997). Seeds are small in size, and weight of 1000 seeds is 0.3 to 0.4g. The crop is versatile in that it is adapted to diverse agro-ecological conditions due in part to its resilience to abiotic stresses such as drought and water logging (Kebebew *et al.*, 2011). Tef grows under a wide range of ecological conditions from sea level to 2800 meter above sea level. It performs best at altitudinal ranges of 1800 to 2100 meter above sea level. The rainfall requirement of the crop varies from 450 to 550 mm.. Tef requires temperatures of 10 to 27 °C and flowers best under 12 hour day length (Seyfu, 1997).

### 2.2. Morphology of Tef

Tef is an annual, leafy, tufted grass that reaches a height of 150 to 200 cm at maturity. The culms are fine, erect, simple or sparsely branched, prone to lodging. The root system is shallow and fibrous. Its leaves are glabrous, linear, 25 to 45 cm long x 0.1 to 0.5 cm wide. The seed head is a long panicle of 10 to 65 cm bearing 10 to 40 slender racemes, which may be either very loose or very compact. Panicles bear 30 to 1100 spikelets. Fruits are ellipsoid, minute (1 to 1.5 mm x 0.5 to 1 mm), yellowish to white to deep brown caryopsis (grain) (Seyfu, 1997). Tef is possibly the smallest cereal grain, with an average length of about 1 mm. The average thousand kernel weight of 12 tef varieties is 0.264 g (Geremew, 2007). The word "tef" is connected by folk etymology to the Ethiopian Semitic root "tff", which means "lost", because of the small size of the grain.



Figure 1: Panicle of wild Tef.  
Source: DZARC, (2008)

### 2.3. Importance of Tef

Tef is used in various forms by Ethiopians, the dominant form of usage is *injera*, unleavened pan cake made of tef flour, which is the mainstay of Ethiopian diet, and also it is consumed in the form of porridge and bread. The nutrient contents of tef are high and primary constituent of protein, amino acids and carbohydrates. Amount of concentration of calcium, iron and zinc more in tef than corn, wheat, or rice (Baye, 2014). In addition, as a cash crop, both the grain and straw of tef fetch higher prices than the respective products from other cereals. Consumers prefer tef not only because it makes good quality ‘injera’, a pancake-like soft bread, but also because it is nutritious due to its high protein and mineral content (Bultosa *et al.*, 2002). Furthermore, the absence of gluten makes tef an alternative food for people suffering from celiac disease (Spaenij *et al.*, 2005). According to Zung, (2004) stated that is particularly important in dealing with diabetes and assisting with blood sugar control. The straw of tef is nutritious and highly preferred feed for livestock compared to the straw of other cereals particularly during dry season. Besides its local use, it is the major cash earning crop for the farming community as market price for both its grain and straw is higher compared to other cereal crops, also among export commodity at national level.

### 2.4. Limitations of the Crop

Regardless of its versatility in adapting to extreme environmental conditions, the productivity of tef is low in Ethiopia at 1.7 tons ha<sup>-1</sup> as compared to 3.9 tons ha<sup>-1</sup> for maize (CSA 2018). The small size of tef seed poses problems during sowing, and indirectly during weeding and threshing. At sowing the very small seed size makes it difficult to control population density and its distribution. This remains true whether one broadcasts the seed by hand, uses a broadcaster or a seed driller (Seyfu, 1997). The uneven plant stand after germination has an impact on nutrient use efficiency of the crop and crop yield. Owing to the scattered plant stand, farmers find it difficult to use mechanical weeding implements and are forced to either hand-weed or use chemical herbicides. Threshers or combine harvesters are used to thresh tef, however, seed loss is incurred because tef seed is very small and light and gets blown away.

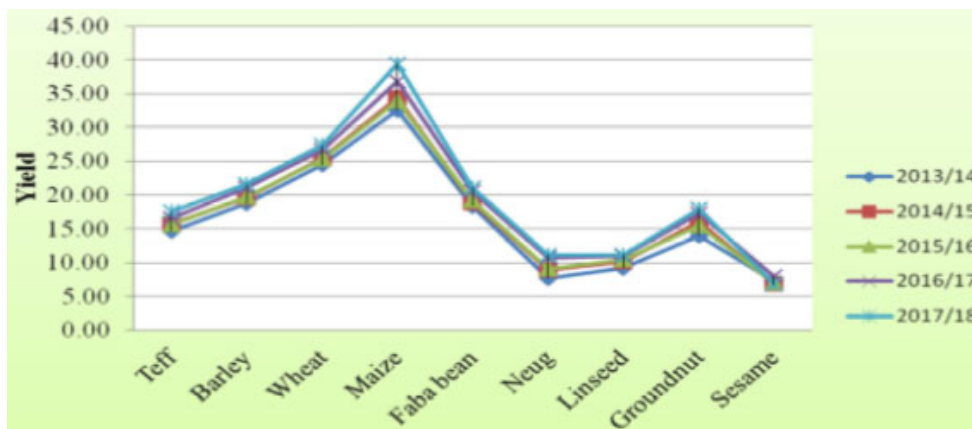


Figure: 2 Tef Productivity (Qha<sup>-1</sup>)  
Source: CSA, (2018)



Figure 3: Types of Tef  
Source: Tareke, (2009).

Lodging or the permanent displacement of the stem from the upright position is the major constraint limiting the productivity of the crop especially when it occurs during the grain-filling period, affects both the quality and quantity of the produce (Seyfu, 1993). Harvesting of the crop is difficult because of lodging. Since tef lodges heavily, it is not advisable to use higher rates of fertilizer to increase yield. The current landraces and cultivars used are not lodging resistant and the development of genetically lodging-resistant cultivars is essential (Seyfu, 1997).



Figure 4. Lodged tef picture  
Source: DZARC, (2008)

## 2.5. Increasing Small Seed Size Technique

### 2.5.1. Seed pelleting

Pelleting is the process of enclosing the seed with small quantity of ingredient along with filter materials is coated to produce a globular unit of standard size to facilitate precision planting. Its methods envelop seed inside a small quantity of inert material just large enough to produce a globular unit of standard size to facilitate planting. The inert material creates natural water holding media and provides small amount of nutrient to young seedlings (Krishnasamy, 2003). Small and irregularly shaped seed can now be treated as larger and round-shaped thereby simulation of seed in the field is therefore easier (Harveson *et al.*, 2007). Pelleting improves the chances of successful germination and seedling establishment under field condition and protect the seed borne fungal and insect attack finally contributing to increased seed yield (Bharathi *et al.*, 2003). There are two components to a seed pellet: bulking coating material and binder. The bulking material can be either being a mixture of several different mineral and/or organic substances or a single component. The coating material changes the size, shape and weight of the seed. Desirable characteristics of a good coating material include: uniformity of particle size distribution, availability of material, and lack of phytotoxicity. The second component, the binder, holds the coating material together (Harveson *et al.*, 2007).

Binder concentration is critical because too much binder will delay germination, whereas too little binder will cause chipping and cracking of pellets in the planter box, which can cause skips and/or wide gaps in the plant rows. Many different compounds have been used as binders, including various starches, sugars, gum Arabic, clay, cellulose, vinyl polymers and even water (Burgesse, 1949). As the demand for pelleted seeds increased, so did the number of companies that produced pelleted seeds, increased competition of pelleted seed market has fostered the development of more effective pellets with greater capabilities and wider plating characteristics. Pellet improvements over the last 10 years include increased O<sub>2</sub> penetration/availability, wider pellet density range, pellet loading, better field visibility. Because of the large increase in volume obtained when seeds are pelleted, pellets have been shown to be effective carriers of plant protectant (pesticides) (Muller and Berg, 2008). The same plant protectant that are often deleterious if applied directly to the seed can be “carried” in the seed pellet. The act of applying a plant protectant in a band within the pellet is known as “pellet loading”. The pellet either acts to “dilute” the negative impact of plant protectant as it moves through the pellet to the seed, or acts as a barrier to prevent direct seed contact. Active products can thus be “loaded” onto the seed while minimizing adverse seed germination effects (Harveson *et al.* 2007).

### 2.5.2. What kind of seeds are pelleted

Seeds of various sizes are commercially pelleted, from relatively large seeds like onion and tomato to very small seeds like lettuce species and tef. For onion, the seed can increase in weight 6-fold due to pelleting; there are approximately 230 raw seeds per gram, and after pelleting the diameter may be 13.5/64th of an inch (0.54cm). The volume for 1000 propagules is 3.7 cm<sup>3</sup> for raw seed compared to 18.0 cm<sup>3</sup> after pelleting. The smallest seed that seed dynamics pellets is *Begonia*. Median seed weight for raw begonia is 88,000 seeds per gram. After pelleting, the seed count can average 857 seeds per gram, an increased mass of over 100-fold.

### 2.5.3. Pelleting material

The materials used for coating should be perfect as the physical integrity of coating is decided by the type of adhesive and this is highly influenced during handling, transport and planting operations of the pellets. According to Howieson *et al.*, (1987) found that the use of poly vinyl pyrrolidone (PVP) is appropriate for coating seeds that will be submitted to impact and abrasion during sowing or those which will be mixed with fertilizers. The coating material must be porous to allow movement of air to the seed, must easily breakdown when it comes in contact with soil moisture, nontoxic, beneficial and harmless to both seed and rhizosphere (Veena, 2007). The methyl celluloses, such as Methofas®, Cellofas® and Methocel®, are non-ionic cellulose ethers, soluble in water, which are recommended because they are semi-synthetic polymers that are economic due to their low use concentrations (Scott, 1989). Silva *et al.*, (2002) also studied bentonite as a binder for pelleting lettuce seeds, at different combinations of bentonite, they found that bentonite aggregates the coating particles and that a 100% use of bentonite, after drying at 36 °C, improved seed quality. There has been a variety of promising products used for pelleting seeds, including microcrystalline cellulose (microcellulose), which is a thin, white, odorless, crystalline powder, originating from partial acid hydrolysis that causes depolymerization of the cellulose chains However, other products are being tested as a coating for pelleting seeds, but their viability will depend on their compatibility with the binders and other materials on the seeds (Almeida, 2004).

Table 1. Types of seed pelleting.

Type	Materials Used
Innoculant Pelleting	Biofertilizer viz, Rhizobia, PSB, <i>Azospirillum</i> , <i>Azotobactor</i> , VAM.
Protective Coating	Biocontrol agent like Rhizobacteria bataticola, Bacillus sp. <i>Streptomyces</i> sp. pesticides, fungicides.
Herbicide Coating	Filler antidote or absorbent coating, Herbicide antidote like 1.8 naphthalic, anahydride (NA)
Nutrient Coating	Coating with micro and macro nutrients. eg. ZnSO <sub>4</sub> , FeSO <sub>4</sub> , Borax
Hydrophilic Coating	Starch graft polymers, magnesium carbonate
Oxygen Supplier Coating	Peroxides of zinc and calcium

Source: Halmer, (2006)

A grower may have a very high yield in a particular field, but not be able to sell a high percent of the crop. Vegetables must meet the standards required by the industry, and demanded by consumers across the country. A uniform, nicely shaped product is usually a must. To get the highest percentage of your crop to meet these standards, precisely planting seed in the soil with the desired amount of space between each seed is critical (Zubair, 2011). Seed pelleting can increase the possibility that the seed will be placed in the soil with the most precision and accuracy possible. The idea behind seed pelleting is to take a seed that is comparatively light in density and oddly shaped and turn it into a seed with a pellet around it that makes that seed heavier, more uniform, and as perfectly round as possible. A planter will be able to plant that seed/pellet in the most accurate and precise way that is mechanically possible (Zubair, 2011). Creating a pellet is both a science and an art: most of the science comes when selecting the powders and adhesive used to create the pellet around the seed. The materials should form a pellet structure that is porous enough to provide immediate oxygen to the germinating seed, and absorb water in a way that is most beneficial to the seed. It is necessary sometimes to have a mixture of 4 or more powders in order to achieve the desired characteristics and also end up with the desired pellet density (Zubair, 2011).

The adhesive is also very important, as it make to be strong enough to hold the powder together, without making the pellet so hard that it slows the germination process. You can also go one step further by putting together the right combination of adhesives and powders to create a pellet that actually splits open much like an egg cracks open. This splitting action is said to lead to even faster oxygen availability and thus less stress on the germinating of seed (Zubair, 2011). There are a couple of ways to create a pellet around a seed, but today the most common method was taken from the candy industry. In this method, seed is placed in a large rolling pan like the one pictured below. The pan is continuously turning and tumbling the seed during this process. The pelleter sprays water until the seed surface is wet. After that, he sprinkles the pelleting powder over the wet, tumbling seed (Zubair, 2011). The powder sticks to the wet seed. The pelleter then sprays adhesive until the seed and powder is again wet. During the process the pellets are removed from the rolling pan several times in order to run them over a sizing screen so that smaller pellets can be built up, while any larger pellets wait outside the pan. This is done until all pellets are exactly the same standard size. Knowing when and how much adhesive to add, and when and how much powder to add is an art that takes some time and practice to perfect (Osted, 2011). Several companies are starting to use machinery that is more mechanized, using less art, but the method described is still the most common pelleting method used in the industry today (Osted, 2011 )



Figure 5: Seed pelleting technology.  
 Source: Osted, (2011)

## 2.6. Uses of Seed Pelleting

Many crop seeds are small and irregular in shape which does not permit the accurate metering by mechanical planting equipments. Pelleting improves the chances of successful germination and seedling establishment under field condition (Bharathi *et al.*, 2003). It protects the seed borne fungal and insect attack finally contributing to increased seed yield (Taylor and Eckenrode, 1993). The original purpose of pelleting was to increase the apparent seed size and weight to alter seed shape for precision planters. In addition to this, pelleting also provides the opportunity for greater loading of material around the seeds and the spatial orientation of active ingredient can be varied within the pellet (Upadhyaya, 2013). Due to small size varied shape of tef, performance of pelleted seeds is influenced by several factors *viz.*, seed coating material, soil and aerial environment.

### 2.6.1. Seed pelleting for accurate sowing.

Further major advantages are that even the smallest seeds when encapsulated in the frozen pellets can be accurately metered during planting operations, precisely positioned and properly spaced. Thus, the amount of seed required can be reduced to a fraction of that previously needed, particularly in view of the significantly improved rate of germination (Tareke, 2010). Precise rows of accurately spaced plants can be attained so as to facilitate subsequent mechanical weeding and cultivation easily done, hence each plant can be assured proper growing room for optimum production, thereby thinning operations can be rendered unnecessary (Tareke, 2010).



Figure 6: pelleted seed tested.

Source: DZARC, (2008)

In view of the foregoing, it should be apparent that the instant invention provides an improved method for planting seeds in which the pellets are particularly adapted for planting crops requiring shallow covering, without regard to soil moisture content. Although the invention has been herein shown and described in what is conceived to be the most practical and preferred method and embodiment, it is recognized that departures may be made there from within the scope of the invention (Tareke, 2010).

## 2.7. Effects Seed Pelleting on Germination

Seed pelleting are physiological seed enhancement methods used on many small seed crops to improve rate of seed germination and seedling performance so as to reduce seed wastage and facilitate the delivery of seeds (Kubik, 2002). Pelleting of seeds with nutrients in pelleting material raised the yield of tomatoes through accelerated growth and development (Konstantinov, 1983). Moreover, during germination tests, it was observed that pelleted

seeds gave seedlings with deeper green and larger leaves as compared to unpelleted seeds. However, pelleted seeds required less time to germinate as compared to unpeeled or uncoated seeds. Moreover the germination percentage was significantly ( $P < 0.05$ ) higher in pelleted seeds than unpeeled seed, further more appears essential for enhanced germination rate and seedling performance (Petch, 1991).

Seeds pelleted with N, P, K, Fe, Cu, Mn, B. and Zn gave 3.4 per cent higher field germination over unpeeled seeds (Konstantinov and Petkov, 1982). According to Balaji, (1990) reported that the seeds pelleted with *Acacia nilotica* improved water holding capacity and pelleting act as a buffer to establish the best soil crop relationship thereby enhancing germination and development of soybean and other crops. Golakiya (1992) reported that pelleting groundnut seeds with polyvinyl alcohol, polyacrelamide and polyacerilic acid improved seed germination even at lower soil water potential. Polyacrelamide was most effective out of three polymers, thus, polymer seed pelleting can be readily used to combat drought whereas, pelleting with lime significantly increased plant growth nodulation, besides protecting the inoculated rhizobia (Eyini and Tayakumar, 1993). Pelleting of wheat seeds with *P. syringae* and *Erhinia hesbicola* prevented the crop against *Fussirium nivale* and pythium and also enhanced the field emergence, plant weight, root length compared to control (Adethyi, 1992).

Bellary onion seeds pelleted with vermicompost, biofertilizers, DAP and micronutrient mixture recorded increased plant height, number of leaves and bulb yield (Ahamed Raza, 1997). According to Mani, (1997) reported that pelleting of seeds with macro and micro nutrients + biofertilizers exhibited quality seedling attributed for elite seedling production in Acacias. Balasubramanian *et al.*, (1998) reported highest fruit yield of tomato at 100 per cent NPK plus (50 kg/ha) plus borax (10 kg/ha) plus composted coir pith (5 t/ha). Suman (2002) revealed that seeds pelleted with  $ZnSO_4$  with or without filler material recorded significantly higher plant height at 50 per cent flowering (69.04 cm) and harvest (81.11 cm) in sunflower.

## 2.8. Effect of Pelleted Seed on Plant Height

Significant differences were reported between the plant heights at different sampling dates throughout the experimental period (Karam, 2004). Variation on plant height due to seed pelleting were detected throughout the experimental period with the exception of sampling date 51 and 93. Farmacyard manure pelleting resulted in the tallest plants compared to clay pelleting and the control through the experimental period; also it is increased plant height by 11% over clay pelleting and by 15% over the control (Karam, 2004).

Table 2. The effect of three types of pellets on plant height on tef crops (cm).

Treatment	Days After sowing					Means
	37	51	65	79	93	
Farmacyard manure pelleting	17.36 <sup>a</sup>	21.13 <sup>a</sup>	30.80 <sup>ab</sup>	37.71 <sup>a</sup>	48.91 <sup>a</sup>	25.18
Clay pelleting	16.61 <sup>ba</sup>	20.74 <sup>b</sup>	30.13 <sup>ab</sup>	35.07 <sup>ab</sup>	38.28 <sup>b</sup>	24.17
Control	13.51 <sup>c</sup>	19.17 <sup>bc</sup>	27.49 <sup>c</sup>	32.82 <sup>c</sup>	36.14 <sup>bc</sup>	21.83
Pr>F	0.16	0.60	0.60	0.379	0.185	
CV (%)	16.77	12.82	14.83	12.04	17.85	

Source: Karam, (2004).

## 2.9. Effect on Seed Pelleted on the Plant Density

The effect of pelleting on number of plants showed that in the following table shows, at day 65 there was a significant difference between the pelleting techniques. This may be attributed to the increased photosynthesis and hydrolytic process in this period, but in the day 37, 51, 79, and 93 there was no significant (Karam, 2004). Pelleting beside conserve moisture around roots, it also contributes by nitrogen found in manure. The report was in accordance with the result revealed by Shama *et al.*, (1969) who stated that nitrogen rates were influence the number of plant.

Table 3. Mean effect of pelleted seed on plant density on tef crops (plant/pot).

Treatment	Days					Means
	37	51	65	79	93	
Farmacyard manure pelleting	9.63 <sup>a</sup>	9.78 <sup>a</sup>	9.78 <sup>a</sup>	9.78 <sup>a</sup>	9.78 <sup>a</sup>	9.75
Clay pelleting	9.48 <sup>a</sup>	9.48 <sup>a</sup>	9.48 <sup>b</sup>	9.48 <sup>a</sup>	9.48 <sup>a</sup>	9.48
Control	8.63 <sup>a</sup>	8.70 <sup>a</sup>	8.74 <sup>bc</sup>	8.6296 <sup>a</sup>	8.70 <sup>a</sup>	8.70
P>F	0.09	0.06	0.04	0.08	0.083	
CV (%)	24.24	22.85	24.86	22.48	22.33	

Source: Karam, (2004).

## 2.10. Effect of Seed Pelleting on Seed Yield

Increased germination and seed yield were noticed due to pelleting of seed with urea and formaldehyde (Usmanov *et al.*, 1981). In the field trials of legumes with various seed treatment, seed pelleting had a significant positive



influence on emergence and seed yield (Zubal, 1986). According to Narasimha, (1994) noted increased seed yield and quality of the resulted seeds of tef crop raised with seeds pelleted with biogas slurry at 500 g per kg. Srimathi *et al.*, (2002) reported that pelleting the seeds with ZnSO<sub>4</sub> at 250 mg per kg of seed improved the initial seed quality and its production potentiality. According to Golakiya, (1992) reported that pelleting seeds with polyvinyl alcohol, polyacrelamide and polyacerilic acid improved seed germination thereby yield of seed, even at lower soil water potential. Polyacrelamide was most effective out of three polymers. Thus, polymer seed pelleting can be readily used to combat drought whereas, pelleting with lime significantly increased plant growth nodulation, besides protecting the inoculated rhizobia (Eyini and Tayakumar, 1993). Pelleting of wheat seeds with *P. syringae* and *Erhinia hesbicola* prevented the crop against *Fussirium nivale* and pythium and also enhanced the field emergence, plant weight, root length compared to control (Adethyi, 1992).

Sorghum seeds pelleted with four different fertilizer increased the germination per cent. In green house, KCl, single superphosphate and lime gave better results than untreated seeds (Magalhaes *et al.*, 1994). Sharma (1995) reported that soil application of calcium increased the plant height of tomato and number of branches per plant. Verma *et al.* (1995) observed highest marketable tomato fruits yield of 285.88 quintals per hectare when 10 kg zinc per hectare was applied. Bose and Tripathi (1996) reported improvement in growth and yield (plant height of 81.56 cm, heighest number of branches of 19 per plant and number of fruits per plant) of tomato Cv. Pusa Ruby at combined application of micronutrients (Zn, Mn, Fe and B) at 30 and 60 days after transplanting.

## CONCLUSION AND RECOMMENDATION

Tef seed is small and its size varies, making sowing more difficult. The small size of tef seed poses problems during sowing, and indirectly during weeding and threshing. At sowing the very small seed size makes it difficult to control population density and its distribution. With tef seed pelleting, the achievements with regard to the pelleting technique so far are encouraging. Therefore, there is a need for further optimization of the pellet manufacturing technique. The pelleting technique increases and homogenizes seed size, but it is essential to determine the physical and physiological characteristics of pelleted seeds. The physiological analysis consisted of: first germination count, final germination, speed emergence index, and seedling emergence. Pellet improvements over the last 10 years include increased O<sub>2</sub> penetration/availability, wider pellet density range, pellet loading, better field visibility. Because of the large increase in volume obtained when seeds are pelleted, pellets have been shown to be effective carriers of plant Protects. Generally application seed pelleting technology for small seed size crops particularly, tef is important for proper planting and maintain planting density of the crop. To this end, research for scientific evident is needed to this technology in the future.

As a recommendation, seed Pelleting is very important techniques to increase precision farming thereby increases the economics of the country, resulted interns livelihood economies by saving quantity of seed required per hectares. It is a new technology of making seeds bigger to increase the singling of seeds to ensure precision planting. Governments and seed processing companies have to play a great role in awareness creation about seed pelleting and its importance in crop production. Researchers have the responsibility to investigate the potential of pelleted seed in yield agricultural system and in improvement of agronomic practices.

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