FACTORES AFFECTING BIOMASS YIELD AND NUTRITIVE VALUE OF FORAGE OAT

A REVIEW

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1. INTRODUCTION

In most tropical countries, inadequate supply of feed is the bottleneck to livestock production (Negash, *et al.,* 2017). This is due to the dependence of livestock on naturally available feed resources and little development of forage crops for feeding animals (Dawit and Teklu, 2014). Like in other tropical countries, in Ethiopia, most of the areas in the highlands of the country are nowadays put under cultivation of cash and food crops. This resulted in keeping large number of livestock on limited grazing area leading to overgrazing and poor productivity of livestock (Irfan *et al.,* 2016). Though, expansion in the cultivation of cereal crops increased the supply of crop residues for animal feeding, crop residues have low nutritive value and could not support reasonable animal productivity (Dawit and Teklu, 2014). Hence, shortage of nutrients for livestock is increasingly becoming serious (Kebede *et al.,* 2016).

One of the alternatives to improve livestock feeding, and thereby enhance productivity of livestock is through the cultivation of improved forages and offer them to animals during critical periods in their production cycle and when other sources of feeds are in short supply (Negash, *et al.,* 2017).The use of cultivated forage crops has received considerable attention for complementing the conventional feed resources especially in areas where feed shortage is the main constraint for livestock productivity (Dawit and Teklu, 2014; Irfan *et al.,* 2016). From the forage crops, due to short life cycle, suitability in crop rotations and better performance on marginal lands, oats **(***Avena sativa L***.)** is an important species for integration into the existing farming system (Dahipahle*et al.,* 2017). Oats can be easily cultivated, develops rapidly, and yields high amounts of dry matter and green forage of higher quality when managed properly.

Oats are forage crop grown at high altitudes (up to 3000 m) on heavy soils (vertisols) where temperate grasses and other improved forages are difficult to establish. The species owes its reputation to its versatility as it can be grown for grain, hay, silage or direct grazing and is being used as feed for dairy cattle, young stock, sheep and goats (Muta*et al.,* 2015). Moreover, it has superior recovery after grazing and is highly useful for overcoming critical periods of feed shortage or for finishing animals for market when permanent pastures are of poor quality (Irfan *et al.*, 2016).

Seed rate, and level of nitrogen fertilizer are key factors, which contribute to the yield and quality of forage oat (Irfan *et al.,* 2016). These conditions vary greatly across the agro-ecological areas (Dawit and Teklu, 2014). Higher fodder yield with fertilizer application is due to their favorable effects on plant water relations, light absorption, crop density, plant height, leaf area and nutrient utilizations (Aravind, 2011). The applications of nitrogen fertilizer improve the dry matter, seed yield and quality of forage (Dawit and Teklu, 2014). Hence, there is a need to determine an appropriate level of fertilizer application especially in soils deficient in nitrogen and proper seeding rate to positively affect forage oat production both in terms of yield and quality (Muta*et al.*, 2015). Hence, this review was initiated with the following objectives:

- To review about factors that affect biomass yield and nutritive value of forage oat *(Avena Sativa L.)*

2. FACTORS THAT AFFECT BIOMASS YEILD AND NUTRITIVE VALUES OF OAT

2.1 General Over View of Forage Oat

Oats *(Avena sativa L.*) are mostly found between 45-65° N and 20-46° S (Stevens *et al.*, 2004). They are grown as a spring-growing or autumn-growing forage crop in the cooler and moister areas of temperate regions and as a cool season crop in Mediterranean and tropical areas (Aravind, 2011). In tropical areas, high altitudes are suitable. In Ethiopia and Kenya, oats are grown above an altitude of 1600 m but do their best above 2000 m (Assefa, 2006; Suttie*et al.,* 2004). Oats grow on a wide range of soils at temperatures ranging from 5 to 26°C and in regions with rainfall over 500 mm (Ecoport, 2013; Assefa, 2006). However, the oat crop is not as winter-hardy as wheat (Kebede *et al.*, 2016).

Hot and dry weather just before heading is deleterious to seed yield. Oats do better in loam soils but tolerate acidic and low fertile soils with pH ranging from 4.5 to 8.6 (Muta*et al.*, 2015). Oats have some salt tolerance (Assefa, 2006; Ecoport, 2013). Because it does not require sophisticated equipment to grow and harvest, oat forage has become a major crop in regions such as the Himalayas (Pakistan, North India and neighbouring countries), the southern cone of South America (Argentina, Brazil, Chile, Uruguay) and North Africa (Irfan *et al.*, 2016). On the contrary, oat forage has declined in areas, notably temperate ones, where mechanized agriculture and maize grown for silage are possible (Suttie *et al.*, 2004).

Oat is winter season forage crop cultivated throughout the country. It is a fast growing, palatable, succulent and nutritious fodder crop (Ecoport, 2013). Fodder oat *(Avena sativa* L.) are presently grown in temperate parts of the world including USA, Canada, Europe and parts of Africa as spring-sown cultivars (Aravind, 2011). In the tropical countries and at higher altitude regions, it is grown as a winter annual. Oat ranks sixth in the world cereal area, production and productivity, followed by wheat, maize, rice, barley and sorghum (Bilal *et al.*, 2017). It is successfully grown in the plains and hilly areas. Fodder oat is a fast growing, high tonnage crop and requires a large quantity of fertilizers (Muta *et al.*, 2015).

2.2 Nutritive Value of Forage Oat

Whole-crop oat forage has a highly variable composition, depending on the stage of maturity, climate and other parameters (Dawit and Teklu, 2014). In general, crude protein varied between 12.0% (DM) at ear formation and 6.3% at the dough stage, and was generally lower than for wheat and barley forage at the same stage of maturity (Ecoport, 2013). Fiber values at ear formation are high (NDF 51% DM, ADF 28% DM) and tend to peak at flowering (NDF 64% DM, ADF 38% DM), before decreasing at the dough stage (NDF 55% DM, ADF 31% DM) (Bilal *et al.,* 2017). Starch content increases from less than 1% to more than 25% DM when the grain is mature. Fresh oat forage cut at the pre-flowering stage was used as the only feed to provide maintenance for rabbits (Dawit and Teklu, 2014).

Oat silage, like other whole-crop cereal silages, differs from grass silage in that the NDF concentration does not increase after heading, but remains constant or even decreases (Ecoport, 2013). However, starch content increases, resulting in OM digestibility values that remain high after heading (Wallsten *et al.,* 2009; Nadeau, 2007). OM digestibility decreases with maturity (from 68% at heading to 61-63% at the early milk or early dough stage), which has been explained by a decrease in NDF digestibility (from 70% at heading to 51% at the early dough stage) (Aravind, 2011). This is compensated by an increase in starch content from 7 to 14% of the DM (Wallsten *et al.,* 2010). The DM intake in 350 kg dairy heifers fed only oat silage increased with plant maturity (`from 1.6 kg/100 kg LW at heading, or early milk stage, to 2.0 kg/100 kg LW at the early dough stage), due to the low water content of the silage in the earlier stages (Wallsten *et al.*, 2009).

2.3 Factors Affecting Production of Forage Oat

The yield limiting factors in forage crops can be divided into several groups: variety efficiency, soil fertility, agro technics, and meteorological conditions (Muta *et al.,* 2015). Oat forage yield and quality are determined by numerous variable factors such as genotype, environment and management practices (Nawaz *et al.,* 2004). Oat forage production is affected by different agronomic factors viz., varieties, fertilizer and row spacing (Kim *et al.,* 2006). Numerous experiments have shown that oats will respond to fertilizer when soil fertility is limiting (Aravind, 2011). In many cases, however, several factors are responsible for less than maximum economic yield (Bilal *et al.,* 2017). Preparation of the seedbed and the planting of a disease- and lodging-resistant variety at a recommended rate are two important factors in determining the potential yield and climatic conditions are also very important (Irfan *et al.,* 2016).

There was an increase in green forage yield of oat genotypes with increase in seed rate from 75 to 125 kg ha-1 (Bilal *et al.,* 2017). Seed rate of 125 kg ha-1 recorded significantly higher total green forage yield (62.29 t ha-1) over rest of the seed rates (Aravind, 2011). However, significantly least total green forage yield was recorded with seed rate of 75 kg ha-1 (51.46 t ha-1) (Kakol, *et al.,* 2003). There was significant increase in green forage yield and dry matter yield with increase in seed rate. The seed rate of 125 kg ha-1 produced significantly higher green forage yield (37.20 t ha-1) compared to 75 and 100 kg ha-1 seed rate (Irfan *et al.,* 2016).

This yield increase was 13.48 %, compared to 100 kg ha-1 seed rate and 20.50 per cent higher, compared to 75 kg ha-1 seed rate (Kakol, *et al.,* 2003). The dry matter yield followed the similar trend recording significantly higher yield of 7.07 t ha-1 with 125 kg ha-1 seed rate (Bilal *et al.,* 2017). This yield increase was mainly due to significantly higher plant height (91.61 cm), number of shoots per meter row length (224.50), fresh weight per meter row length (1237.33) and number of seedlings per meter row length recorded with 125 kg ha-1 seed rates (Kim *et al.,* 2006).

There was significant increase in dry matter yield of oat with increase in seed rate from 75 to 125 kg ha-1 (Muta *et al.,* 2015). Seed rate of 125 kg ha-1 recorded significantly higher total dry matter yield (11.83t ha-1) over rest of the seed rates (Kakol, *et al.,* 2003). However, significantly least total dry matter yield was recorded with seed rate of 75 kg ha-1 (9.78 t ha-1) (Kebede *et al.,* 2016).Increasing seed rate from 50 to 75 kg per ha resulted in higher green forage as well as dry matter yield (Bilal *et al.,* 2017). Similarly, higher seed rates (100 and 125 kg/ha) did not bring any improvement in the forage yield over 75 kg per ha (Kim *et al.,* 2006). Kakol, *et al.,* (2003) reported that, the fodder yield was not affected by seed rate and 50 kg per ha seed rate gave equal fodder yield as 100 kg per ha with four nitrogen levels (0, 40, 80 and 120 kg/ha) (Aravind, 2011).

Kim *et al.* (2006) reported that dry matter yield did not increase beyond 45 kg per ha seed rate although higher seed rates did increase the yield at initial defoliation (Muta *et al.,* 2015). Significantly higher green forage and dry matter yield with 125 kg per h seed rate as compared to 100 kg per ha when tried with two sowing methods at four nitrogen levels (0, 50, 100 and 150 kg per ha) (Irfan *et al.,* 2016). Aravind (2011), observed increase in dry matter with increasing sowing rates up to 500 kg per ha at early harvests while later in the season there was no significant difference between the two highest sowing rates (100 and 500 kg/ha) (Dawit and Teklu, 2014). The green forage and dry forage yields were not much affected by sowing rates of 40, 60, 80, 100 or 120 kg seed per ha (Bilal *et al.,* 2017). Whereas, higher green forage yield was obtained with 120 kg seed per ha (Kakol, *et al.,* 2003).

With increase in level of seed rate there was a decrease in organic matter content during different ages of harvests (Kebede *et al.*, 2016). Significantly higher organic matter content was recorded with seed rate of 75 kg per ha (91.23%) (Kim *et al.*, 2006). However, higher seed rate of 125 kg per ha recorded significantly lower organic matter content (90.27% (Muta *et al.,* 2015). Higher crude protein content was recorded with seed rate of 125 kg per ha during first harvest (7.82%) and second harvest (6.19%) (Aravind, 2011). It was on par with 100 kg per ha seed rate during first harvest. However, lower seed rate of 75 kg per ha recorded significantly lower crude protein content (7.55 and 5.97% during first and second harvests, respectively) (Bilal *et al.,* 2017).

Significantly higher crude protein yield was recorded with seed rate of 125 kg per ha during first harvest (556 kg ha-1), second harvest (287 kg ha-1) and total of two harvests (843 kg ha-1) (Muta *et al.,* 2015). However, lower seed rate of 75 kg per ha recorded significantly lower crude protein yield (444, 229 and 672 kg ha-1 during first, second and total of two harvests, respectively) (Irfan *et al.,* 2016).Significantly higher ether extract content was recorded with seed rate of 125 kg per ha during first harvest (2.25%) and second harvest (2.49%) (Dawit and Teklu, 2014). However, lower seed rate of 75 kg per ha recorded significantly lower ether extract content (2.17%) (Kim *et al.*, 2006).

There was significant increase in ether extract yield with increase in seed rate level. Significantly higher ether extract yield was recorded with seed rate of 125 kg per ha (277 kg ha-1) (Dawit and Teklu, 2014). However, lower seed rate 75 kg per ha recorded significantly lower ether extract yield (128, 91 ha-1) (Muta *et al.*, 2015).During first and second harvest, significantly lower crude fiber content was recorded with seed rate 125 kg per ha (20.00%) (Kebede *et al.*, 2016). However, seed rate of 100 kg per ha recorded significantly higher crude fiber content during first harvest (21.27%) and it was on par with 75 kg per ha seed rate. Seed rate of 75 kg per ha recorded significantly higher crude fiber content during second harvest (30.60%) and it was on par with 100 kg per ha seed rate (Dawit and Teklu, 2014).

There was linear increase in crude fiber yield with increase in seed rate (Dahipahle *et al.*, 2017). During harvests, significantly higher crude fiber yield was recorded with seed rate of 125 kg per ha (2762 kg ha-1), but lower seed rate of 75 kg per ha recorded significantly lower crude fiber yield (1206 kg ha-1) (Aravind, 2011).As reported by Kim *et al.* (2006), there was linear and significant increase in total ash content with increase in seed rate. Significantly higher total ash content was recorded with seed rate of 125 kg per ha (9.73%). However, lower seed rate of 75 kg per ha recorded significantly lower total ash content (8.78%) (Dahipahle *et al.*, 2017).

The total ash yield increased significantly with increase in seed rate in different harvests. Significantly higher total ash yield was recorded with seed rate of 125 kg per ha (699 kg/ha) (Kim *et al.*, 2006). However, lower seed rate of 75 kg per ha recorded significantly lower total ash yield (861 kg/ha). As Kim *et al.* (2006) finds significantly higher nitrogen free extract content was recorded with seed rate of 75 kg per ha (60.49%) (Dawit and Teklu, 2014) over rest of the seed rates significantly least nitrogen free extract content was recorded with seed rate of 125 kg per ha (59.60%) (Bilal *et al.*, 2017).

There was linear and significant increase in nitrogen free extract yield with increasing level of seed rate. Significantly higher nitrogen free extract yield was recorded with seed rate of 125 kg per ha (4203kg ha-1) (Kim *et al.* 2006), However, lower seed rate 75 kg per ha recorded significantly lower nitrogen free extract yield (3547kg ha-1) (Muta *et al.,* 2015). During first and second harvests, there was linear and significantly decrease in total carbohydrate content with increase in seed rate. Significantly higher total carbohydrate content was recorded with seed rate of 75 kg per ha during first and second harvests (81.14% and 82.59%, respectively) (Bilal *et al.,* 2017).

However, higher seed rate of 125 kg per ha recorded significantly lower total carbohydrate content (79.60% and 81.42%, respectively) (Dahipahle *et al.,* 2017). During first, second and total of two harvests, significantly higher total carbohydrate yield was rerecorded with seed rate of 125 kg per ha (5601, 3783 and 9384 kg ha-1, respectively) (Aravind, 2011). However, lower seed rate of 75 kg per ha recorded significantly lower total carbohydrate yield during first, second and total of two harvests (4754, 3129 and 7883 kg ha-1, respectively) (Irfan *et al.,* 2016).

Nitrogen is the major nutrient for plants and becoming deficient in soils which is being supplemented by inorganic nitrogen fertilizers *(*Kim *et al.* 2006). The molecular forms of nitrogen can be made available to crops through industrial and biological process (biological nitrogen fixation) (Irfan *et al.,* 2016). The former process consumes the fossils fuels, degrades the soil and environment health through CO2 and NO2 enrichment and later is naturally eco-friendly which is carried out by prokaryotic micro-organisms (Bilal *et al.,* 2017). It has been estimated that half of the applied nitrogen is lost in various processes (Pindi, 2012). It is obvious that synthetic fertilizers cannot be put out from agriculture without compromising the low yield but these must be integrated with bio fertilizers (Muta *et al.,* 2015).

Application of organic and inorganic fertilizers contributed greatly towards the growth and yield contributing attributes of the oat (Aravind, 2011). Nevertheless, the application of inorganic fertilizers surpassed in enhancing growth, yield and quality attributes then the organic fertilizer application (Bilal *et al.,* 2017). While organic fertilizers are more environmental friendly and reduce the risk of pollution then the inorganic ones. Makhash *et al.* (2008) reported that increasing the level of N enhanced the plant height and number of leaves as compare to the low levels of N fertilizer (Kebede *et al.,* 2016). The increase in plant height with different N levels can be attributed to the fact that N promotes plant growth, increase the number and length of the internodes which results in progressive increase in plant height (Gasim, 2001).

The GFY increased with increasing fertilizer levels. Maximum GFY was recorded at higher N dose (120 kg ha^{-1}).Ahmad *et al.* (2011) observed the considerable increase in yield with increasing the level of N. The results are accordance with the findings of Iqbal *et al.* (2013) who also reported that120 kg N ha^{-1} enhanced the maximum yield of oat crop (Irfan *et al.,* 2016).The N has direct effect on GFY and DMY (Muta*et al.,* 2015). The current finding indicates that effect of N level are in agreement with the results of Bassegio *et al.* (2013). The N dosage positively affected number of leaves. The higher dose (120 kg N ha^{-1}) produced more number of leaves as compared to lowest, (60 kg N ha^{-1}) at successive growth stages and years (Aravind, 2011).

Plant height and number of leaves per plant are major attributes that involved in the forage yield of crop that associated with growth and biomass (Bilal *et al.,* 2017). Total green forage yield of oat also increased linearly and significantly with increase in nitrogen level from 90 to 150 kg ha-1 (Dawit and Teklu, 2014). Application of nitrogen at 150 kg ha-1 recorded significantly higher total green forage yield (62.58 t ha-1) compared to lower doses and similar trend was noticed during first (38.44 t ha-1) and second (24.14 t ha-1) harvests (Irfan *et al.,* 2016). Significantly least total green forage yield (51.27 t ha-1) was recorded with 90 kg ha-1 nitrogen (Bilal *et al.,* 2017).

The N has direct effect on GFY and DMY (Ahmad *et al.,* 2011). Bassegio *et al.* (2013), observed the considerable increase in yield with increasing the level of N. The highest DM of 32.4 and 40.9% was recorded at higher N rate (120 kg ha^{-1}) at successive growth stages

(Irfan *et al.,* 2016). Wang *et al.* (2002); Iqbal *et al.* (2009) observed that N application significant improved the DM content. Nitrogen fertilizer was found more efficient with respect to plant height, number of leaves, biomass traits, green forage yield, dry matter yield and dry matter content than other tested varieties (Dawit and Teklu, 2014). The highest N rate (120 kg ha^{-1}) significantly affected above parameters than low level (60 kg N ha^{-1}) (Muta *et al.,* 2015). The plants supplied with highest dose of nitrogen bear more leaves and therefore, produced the highest leaf to stem ratio. Fertilizing crop with 80 kg N/ha was the optimum rate for the highest DMY (Aravind, 2011).

It is concluded that nitrogen enhances the merismetic and photosynthetic activity by regulating up the cell elongation and division and chlorophyll contents of leaves and it reflects the higher DMY (Muta *et al.*, 2015). It appears that likewise plant height, DMY must be at the maximum with 120 kg N/ha (Bilal *et al.*, 2017). But actually it did not happen because plants might have greater tendency of lodging and hence cannot contribute effectively to yield (Irfan *et al.*, 2016). Nitrogen management will have the most impact on final oat grain size and weight. Applications made early will ensure a canopy that is large, containing high levels of stem carbohydrate that is translocated to the developing grain during maturation (Aravind, 2011). It is important to monitor plant nitrogen levels ensuring the canopy does not senesce early and curtail the grain filling period (Kebede *et al.,* 2016).

The number of leaves and shoots determines the size of the canopy and the final number of ears at harvest (Dawit and Teklu, 2014). The most important macro nutrients for early shoot, leaf growth, and shoot survival are nitrogen, phosphate, and sulphur (Bilal *et al.,* 2017). Nitrogen is the single most important nutrient for achieving high yields (Muta *et al.,* 2015). Adequate supplies will give more shoots and bigger leaves, with each leaf developing faster (Aravind, 2011). Nitrogen deficiency on the other hand reduces the rate of primordia initiation, which reduces the number of potential spikelets (grain sites). The N dosage positively affected number of leaves (Irfan *et al.,* 2016). The higher dose (120 kg N ha^{-1}) produced more number of leaves as compared to lowest, (60 kg N ha^{-1}) at successive growth stages and years [Beyene *et al.* (2015); Lodhi *et al.* (2009); Mekasha *et al.* (2008)].

Plant height and number of leaves per plant are major attributes that involved in the forage yield of crop that associated with growth and biomass (Zaman *et al.,* 2006). Bakhsh *et al.* (2007) also reported that variation in environmental conditions and genetic makeup cause the variation in plant height and number of leaves (Muta*et al.,* 2015). The maximum plant height was because of plant enjoying of full benefits of available resources and sunlight as compared to dense population (Rasul *et al.*, 2012). Ayub *et al.* (2013) found that increase the N levels increased the morphological traits.

Ahmad *et al.* (2011) narrated that increasing the level of N enhanced the plant height and number of leaves as compare to the low levels of N fertilizer (Aravind, 2011). The increase in plant height with different N levels can be attributed to the fact that N promotes plant growth, increase the number and length of the internodes which results in progressive increase in plant height (Gasim, 2001). The amount of nitrogen applied essentially depends on the amount of available nitrogen in the soil (Dawit and Teklu, 2014). In soils with high humus (organic matter) content, oats may get all the nitrogen from these nitrogen reserves, however, in intensive cultivation on mineral soils the amount of nitrogen applied will usually be between 40 kg/ha and 150 kg/ha (Bilal *et al.,* 2017).

Typically nitrogen will double or even treble the yield achieved. This extra yield comes from the improved size and duration of the photosynthesizing leaf canopy, and the increased tillering that leads to correct number of spikes per unit area (Aravind, 2011). For every tiller that is initiated extra roots develop so sufficient applications of nitrogen also increase the ramification of the roots, improving the water and nutrient uptake by the plant (Irfan *et al.,* 2016). The survival of the shoots / tillers that are produced can be influenced by interactions between nitrogen application rates and timing (Muta *et al.,* 2015). Where shoot numbers are below the optimum, the applications of higher nitrogen rates early in the growing season will increase shoots and thereby final ear numbers (Aravind, 2011). This crop manipulation should not be used where plant populations are on target, as it can lead to excessive leaf and shoot growth and lodging (Kebede *et al.,* 2016). Lower application rates early should be used where shoot numbers are on target. Increasing the nitrogen levels enhanced green forage yield for long period of time (Bilal *et al.,* 2017).

Ahmad *et al.* (2011) recorded more number of shoots at 150 kg N per ha over that of 50 and 100 kg N per ha. Enhancing level of nitrogen from 0 to 160 kg per ha caused for increased number of shoots significantly between 70 and 115 days after sowing (Aravind, 2011). Ahmad *et al.* (2011) also reported maximum number of tillers per meter square area with nitrogen at 160 kg per ha (Muta *et al.*, 2015). Singh (1992) indicated that number of shoots increased with increased level of nitrogen at all growth stages. Ayub *et al.* (2013) recorded more number of shoots at 120 kg N per ha than 80 Kg N per ha. Beyene *et al.*, (2015) reported that number of shoots increased with nitrogen up to 120 kg per ha and significantly reduced at 160 kg N per ha (Irfan *et al.*, 2016).

Oat protein content can be increased if nitrogen and sulphur fertilization is optimized. The energy content of unhulled oat is lower than that of other cereals. The feed value of oat can be improved by hulling (removing the husk from the grain/kernel) it before use, after which its feed value is comparable with corn and wheat (Aravind, 2011). The share of the husk in the weight of the grain varies between 23% and 30% and also oats contains more fat (5-7%) than other cereals (Bilal *et al.*, 2017). The fatty acid composition of oat is better than that of other cereals. This high fat content makes oat a valuable, energy rich fodder cereal for feeding all kinds of animals (Irfan *et al.*, 2016). Oats contains more raw protein than other cereals with particularly high levels of lysine (Kebede *et al.*, 2016). Their high fiber content is good for poultry promoting good digestion and gizzard activity which keeps the birds calm (Muta *et al.*, 2015).

The proportion of oats in the chicken feed mixtures is about 20%, but its share can be increased to 50% towards the end of the egg laying season. Oats also improve the quality of the egg shell as well as the fatty acid composition and nutritional value of the eggs. Oats are also beneficial for sows and piglets (Kebede *et al.*, 2016). Adding oat to the feed mixtures of pigs improves their stomach health, prevents diarrhea, constipation and gastric ulcers. Hulled oats are a good raw material for piglet feed (Dawit and Teklu, 2014).Nitrogen and sulphur fertilization is important for the feed value of oat fodder as both have improved live weight gain for livestock when the applications are optimized (Irfan *et al.*, 2016).

Nitrogen and Potassium are the most influential of the macronutrients on grain quality (Dawit and Teklu, 2014). Nitrogen is important for grain size and protein content whilst potassium maintains the crop structure to prevent lodging that reduces grain size and specific weight (Kebede *et al.,* 2016). Beside nitrogen role in synthesis of amino acids, the higher leaf to stem ratio at highest level of nitrogen is another support for higher protein concentration in dry matter as leaves contain more protein than stems (Aravind, 2011). Nitrogen, being an essential component of chlorophyll, hormones, enzymes and amino acid improved the growth, dry matter yield and protein concentration (Muta *et al.,* 2015). The ether extractable fat showed a negative relation with nitrogen application rates and its concentration in dry matter was dropped (Bilal *et al.,* 2017).

The plots sown with inoculated seeds and received 120 kg N/ha produced 19.01% more crude protein over untreated seed (Kebede *et al.,* 2016). Furthermore, the protein contents obtained at 120 kg N/ha can be achieved with 80 kg N/ha and inoculums which saved 40 kg N (Muta *et al.,* 2015). Similar results were reported by Kader *et al.* (2002) who stated that inoculating the wheat seeds with bio fertilizer helped to reduce the use of nitrogenous fertilizer up to 20%. The study of Aravind (2011), shows that the contribution of inoculation to improve the DMY, CP and CPY (Irfan *et al.,* 2016). It was revealed that inoculum positively contributed for DMY and CPY improvement up to 80 kg N/ha while for CP (%) this rate was 120 kg N/ha and it suggested that further treatments may be designed to find the maximum rate (Bilal *et al.,* 2017; Irfan *et al.,* 2016).

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