Journal of Current Research in Food Science 2020; 1(2): 47-52

JOURNAL OF CURRENT RESEARCH IN FOOD SCIENCE

E-ISSN: 2709-9385
P-ISSN: 2709-9377
JCRFS 2020; 1(2): 47-52

www.foodresearchjournal.com
Received: 28-05-2020
Accepted: 30-07-2020

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Review on the effects of seed rates on growth, yield components and yield of bread wheat (*Triticum aestivum* L.)

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Abstract
Wheat (*Triticum aestivum* L.) is one of the important grain crops produced worldwide. In Ethiopia bread wheat (*Triticum aestivum* L.) is one of the most important cereal crops cultivated primarily for human consumption. It has been recognized as strategic food security crop and contributes about 16% requirement in the country. Wheat is the leading cereal grain produced, consumed and traded in the world today. Seed rate are the most important management factor affected the agronomic characteristics of wheat. Seeding rate can impact on wheat tillering, grain yield and protein quality. Wheat quality was not reduced at higher seeding rates as protein content, kernel weight and test weight were unaffected. At the highest seeding density, the increased intra-plant competition may have also contributed to the reduction in plant height. Hence, achieving higher agronomic performance and better end-use quality requires optimizing and periodically reviewing management practices such as seeding rates. However, in cultivars that produce fewer tillers, higher seeding rates compensated for reduced tiller and promoted more main stem spikes.in a dense wheat population, grain yield.in a dense wheat population, grain yield decreased due to competition between plants that induced self-regulation. Wheat yield also affected by growth and seed rate. So optimum seed rate is recommended for increasing wheat production and productivity.

Keywords: bread wheat, growth, seed rate, yield component

1. Introduction

1.1. Background and Justification

In Ethiopia bread wheat (*Triticum aestivum* L.) is one of the most important cereal crops cultivated primarily for human consumption (FAO, 2014) [20]. Wheat is cultivated approximately on 1.7 million hectares of land and ranks fourth next to teff, maize and sorghum both in production and area coverage in Ethiopia. It accounts for about 15.17% of the total cereal production with area coverage of 13.38% in the country (CSA, 2016) [16]. It is widely grown in the mid and highland altitudes within range of 1500 to 3000 meter above sea level in Ethiopia (MOANR, 2016) [40].

Wheat crop can grow in different soil types ranging from desert soil to heavy clay soil. However, well drained, fertile clay loam soils having moderate water holding capacity are ideal for better production of wheat crop Ethiopia is the largest wheat producer in sub-Saharan Africa solely under rain fed condition (Netsanet *et al*., 2016) [41]. Enormous number of improved varieties of wheat were released from research institution by breeders in the country (MOANR, 2016) [40]. In this regard, inappropriate crop management practices such as low seed rate, improper row spacing, delay in sowing and traditional sowing methods are found to be the key elements contributed to low productivity of wheat crop (Iqbal *et al*. 2010) [28]. For instance, in Ethiopia wheat is planted in broadcast by smallholder farmers for many decades. However, in developed countries where implementation of farm machineries is available drilling wheat and other crop in row with optimum spacing is common. Row planting result in uniform seed distribution and planting at desired depth and space which usually results in higher germination and uniform stand of the crop (Umed *et al*., 2009) [55]. Higher wheat grain yield with better quality requires appropriate seeding rate and optimum row spacing for different cultivars. Increase in seed rate above optimum level may only enhance production cost without any increase in grain yield (Rafique *et al*., 2010) [44].

1.2. Objective of the review

To review the effects of seed rates on growth, yield components and yield of bread wheat.

2. Literature review

2.1 Origin and botanical description of bread wheat

Bread wheat believed that originated in south western Asia from where it spread to other parts of Asia (Feldman, 2001) [21]. Wheat is a tall, annual plant with a height ranging from two to six feet in early varieties and The grain may also vary in its length of brush hairs, either long or short and Cultivated is most commonly grown with physical characteristics of fusiform spikes, are awned (bearded) and are easily threshed (McKevith, 2004) [37].

2.2 World wheat production

Wheat is the leading cereal grain produced, consumed and traded in the world. (Hazelton, P. 2007) [26]. The cultivation of wheat is thought to have begun several thousand years before the birth of Christ; and bread, leavened and unleavened has been a staple food for humans throughout reported history (Firdissa Eticha. 2015) [22, 29]. Cereal grains are commonly designated as either food (wheat and rice) or feed/coarse grains (corn, barley, sorghum, etc.), based on their primary end-use and it is the leading grain produced, averaging 533 MMT annually, representing almost one-third of all cereal production (Chapman & Hall 2007) [12].

2.3 Wheat production in Africa

During 2009-2011, Africa produced about 23 million tons of wheat and imported about 36 million tons, creating a huge food gap between supply and demand (59 million tons) (Harold, 2015). The comparable values for countries south of the Sahara are 5.6 million tons in average production and 12.7 million tons in imports (Phillips and Norton, 2012) [43]. Economic and demographic changes have led to rapid growth in wheat demand and dependency on wheat imports, which may also increase vulnerability of countries in the region to political instability as food prices escalate (Asfaw, *et al*, 2013) [8].

2.4 Wheat production in Ethiopia

Bread wheat is one of the major cereal crops in the Ethiopian highlands that lie between latitude from 1500 to 3000 masl the most suitable areas for wheat production however fall between 1900 and 2700 masl (Hailu, 2003). In Ethiopia, wheat covered an area of 1,706,323.86 ha with a total production of 40, 391, 13.674 tons with yield average of 2.35 t ha^{-1} during 2012/2013 main cropping season (meher) (CSA, 2013) [14]. Wheat production grew by 37 percent between 2010/11 and 2013/14, and reached at 3.93 million metric tons in 2013/14 (CSA, 2015c) [15]. Wheat production, however, concentrates in two regions. This contributes to the geographical dispersion of wheat-surplus and deficit areas in the country. The major surplus areas of wheat are zones (provinces) in Oromia and SNNPR, namely Bale, East Arsi, West Arsi, Western and Eastern Shoa, Central SNNPR (Hadiya and Kembata) and Central and Southern Amara (East Gojam, North Shoa) (FAO, 2014) [20]. Two-thirds of the zone-level surpluses come from just four zones: Bale, Arsi, West Arsi, and East Gojam (Minot *et al.*, 2015) [39].

The climate encourages rapid and abundant growth of weeds and consequently, all agricultural crops are heavily infested with weeds. Farmers in the country are aware of weed problem in their fields but often they cannot cope-up with heavy weed infestation during the peak-period of agricultural activities because of labor shortage, hence, most of their fields are weeded late or left un-weeded. Such ineffective weed management is considered as the main factor for low average yield of wheat resulting in average annual yield loss of 35% (Esheteu., 2006) [18].

In addition to the grain, the straw of bread wheat is used for animal feed, thatching roofs and bed decking. In spite of its tremendous importance, wheat production in Ethiopia faced immense production constraints that are affecting both its yield potential and industrial quality (Amare *et al*., 2015) [5]. In Ethiopia wheat is predominantly grown by small scale farmers at a subsistence level, The average productivity of wheat in Ethiopia is still low; about 2535 kg^{-}ha as which is much below that of the world's average about 2900 kg ha^{-1} (CSA, 2016) [16]. Among the factors responsible for low wheat yield, delay in sowing, traditional sowing methods, low seed rate and improper row spacing are very important (Iqba *et al*., 2010) [28].

2.5 Importance of bread wheat

Bread Wheat is one of the three cereals which has the most cultivated land in the world and dedicated to itself about one-third of the world's arable land (Emam, 2007) [17]. Wheat is grown on more land area than any other food crop (220.4 million hectares, (FAO, 2014) [20]. This plant has an important role in feeding people around the world (Ying *et al*., 2016) [58]. Bread wheat is the source of flour for breads, chapattis, semolina, biscuits and other confectionary products. Wheat grain is also used to manufacture alcoholic beverages. Bran from flour milling is used in livestock feed and the germ is a valuable addition to feed concentrate. Grains are fed to livestock whole or coarsely ground. The wheat plant is also used as a pasture feed before stem elongation and this practice permits plant regeneration and grain harvest. Wheat straw is also used as a source of fiber. The comparatively high protein content of wheat grain makes it a most important source of human nutrition. World trade in wheat is greater than for all other crops combined (Rajaraman and Mac, 2002). Bread Wheat is an important source of carbohydrates (Shewery, Hey, 2015) [49]. Globally, it is the leading source of vegetal protein in human food, having a protein content of about 13%, which is relatively high compared to other major cereals (CODIS, 2016). But relatively low in protein quality for supplying essential amino acids. When eaten as the whole grain, wheat is a source of multiple nutrients and dietary fiber (Shewery, Hey, 2015) [49].

2.6 Effects of seed rate on growth, yield components and yield of bread wheat

Seeding rate can impact on wheat tillering, grain yield and protein quality (Staggenborg *et al*., 2003) [51]. Hence, achieving higher agronomic performance and better end-use quality requires optimizing and periodically reviewing management practices such as seeding rates (Brian *et al*., 1615). It was reported that, in a dense wheat population, grain yield was decreased due to competition between plants that induced self-regulation (Jennifer *et al.*, 2006). However, in cultivars that produce fewer tillers, higher seeding rates compensated for reduced tiller and promoted more main stem spikes (Staggenborg *et al.*, 2003) [51]. Wheat quality was not reduced at higher seeding rates as protein content, kernel weight and test weight were unaffected (Jennifer *et al.*, 2006: Bryan, 2001) [11].

2.6.1 Effects of seed rates on growth and phenological parameters of bread wheat
Phenological parameters
2.6.1.1 Days to 50% heading
Gaffar (2007) who reported that increasing sowing density from 200 up to 400 grains per meter square in wheat crop significantly decreased the number of days to 50% heading. Jemale *et al.*, (2015) reported that increasing seeding rates from 100-200 kg ha^{-1} grains caused a significant increase in the number of days from sowing to 50% heading in wheat. Tewodros *et al*., (2014) [54] who reported that days to heading showed significant difference among wheat varieties.

2.6.1.2 Days to 90% physiological maturity
Alemayehu (2015) [2] and Abiot (2017) [1] who reported that increasing seed rate from 100 to 150 kg ha^{-1} decreased days to 90% physiological maturity. The result is also in agreement with Melaku (2008) [38] who reported that increasing levels of seed rate promoted early physiological maturity of bread wheat. In contrast, Seleiman *et al*. (2010) [48, 53] and Jemale *et al*. (2015) reported that increasing seeding rates from 250-400 m–2 and 100- 200 kg ha-1 grains prolong the number of days from sowing to maturity of wheat, respectively.

2.6.1.3 Growth parameters
Plant height (cm) seed rate are the most important management factor affected the agronomic characteristics of wheat (Ansari *et al.*, 2006; Marwat *et al*., 2002) [6, 36]. The decrease in plant height in response to lowering the seeding rate to 100 kg ha^{-1} may reflect formation of more secondary tillers in less populated stands, which tend to be shorter in stature. At the highest seeding density, the increased intra-plant competition may have also contributed to the reduction in plant height (Chaudhary *et al,* 2000) [13]. Haile *et al*. (2013) [24] reported that plant height increased with increasing seeding rate. Higher seeding rate caused to changing plant height and stem thickness because of the lower light penetrating in to the plants canopy bed and more inter specific competition to more absorption light. These factors (higher seeding rate and lower light penetration) increasing inter node length, reducing stem thickness and increasing plant height (Otteson *et al.*, 2007) [42].

2.6.1.4 Spike length (cm)
Baloch *et al*. (2010) [10] reported that different seed rate had no significant effect on spike length. Furthermore, Zewdie *et al.* (2014) [59] reported that plant height and spike length are negatively related. Shorter plant produce longer spike and long plant produce shorter spike.

2.6.2 Effects of seed rates on yield components and yield of bread wheat
2.6.2.1 Effective tiller number
Crop yields are generally dependent upon many yield contributing agents. Among these, number of effective tillers is the most important because of the final economic yield of most of the cereals is determined by the number of fertile tillers Higher seed rate produced many number of tillers but it might not produce many numbers of effective tillers per unit area due to competition of tillers for growth factors that lead to the production of low numbers of productive tillers per unit area (Baloch, 2002) [9]. Alemayehu (2015) [2] who reported that maximum productive tiller from minimum seed rate and vice versa. Similarly, Rahel and Fekadu (2016) [45] reported that maximum productive tiller was reported from lower seed rate than higher seed rate because of productive tiller per plant higher at lower seed rate than higher seed rate. By increasing seed rate the number of grains per spike is reduced (Khan *et al*, 2002) [32, 36]. Khan *et al,* (2002) [32, 36] concluded that by increasing seed rate the 1000-grains weight is reduced. These results are in analogy with the findings of earlier workers (Arif *et al.*, 2003; Khan *et al*., 2001) [7, 33] who reported higher yield with seed rate of 150 kg ha^{-1}, however disagree with those of Rafique *et al.* (2010) [44] who concluded that seeding rates did not influence the grain yield of wheat. Furthermore, Sarker *et al.* (2007) [52] reported that at higher seed rates, competition among the plants started before maximum tillering stage, which was manifested in low increase in tiller production. However, this was in contrast with Jemal *et al.*, (2015) [29] who reported that maximum effective tiller number was reported from the higher seed rate than the lower seed rate.

2.6.2.2 Number of kernels (Grains) per spike (NKPS)
Rahim *et al*. (2012) [47] who reported that higher seed rates produced significantly decreased number of grains (kernels) spike. Majid and Mohsen (2012) [35] who reported that significant differences were found among varieties in terms of the number of kernels spike. However, this was in contrast with Igorpirez *et al.* (2013) who reported that the wheat genotypes did not influence the number of grains per ear obtained in distinct seeding densities.

2.6.2.3 Number of seeds per spike
In the report of Worku, (2008) [57] number of seeds per spike was counted from ten randomly selected plants from the middle rows of each plot and the mean number was taken at harvesting. In this report increasing the rate of seeding decreased the number of grains per spike. Hussins and (Pan, 200) reported that the number of kernels per spike decreased with an increase in seeding rate.

2.6.2.4 Thousand seed weight
Fani *et al.* (2014) [19] showed that at high densities thousand seeds weight declined whereas in low densities, seed thousand weights increased. Baloch *et al.* (2010) [10] Reported that the higher the seeding rate in bread wheat resulted in decreased thousand seed weight. This may be due to the vigorous seeds as lower intra competition in wider spacing and lower seed rate. The current result is in agreement with Spink *et al*. (2000) [50], Baloch *et al*. (2010) [10] and Laghari *et al*. (2011) [34] who reported that the higher seed rate in bread wheat resulted in decreased 1000-kernel weight. Furthermore, Jemal *et al*. (2015) [29] reported that increasing seeding rate significantly decrease 1000-kernel weight. However, the current result is in contrast with Veselinka *et al*. (2014) [56] who reported that 1000-seed weight was increased with increasing seeding rate in studied varieties of winter wheat. Maximum thousand seed weight (41.3 gm.) was reported from a seed rate of 100 kg ha-1, while minimum thousand seed weight was reported from a seed rate of 150 kg ha-1 which is (39 gm.) followed by 125 kg ha-1 which is (39.6) Veselinka *et al*. (2014) [56].

2.6.2.5 Biomass yield (t ha^{-1})
Rahel and Fekadu (2016) [45] who reported that maximum biomass yield was reported at seeding rate of 100 kg seed ha^{-1} than 125 and 150 kg ha^{-1}. Similarly, Allam (2003) [4] reported that, in wheat higher seed rates, higher number of plants and tillers failed to produce higher biomass yield. In contrast Alemayehu (2015) [2] and Jemal *et al*. (2015) [29] were reported that maximum biological yield at higher seed rate than lower seed rate.

2.6.2.6 Grain yield (t ha^{-1})
Haile *et al.* (2013) [24] reported that the lower seed rate resulted in lower grain yield while higher yield was due to higher seed rate. Ali *et al.* (2010) [3] explained that lower seeding rates significantly increased the number of grains and vice versa. The current result is in agreement with Rahel and Fekadu (2016) [45] who reported that the maximum grain yield 2.78 t ha-1 was obtained in plots seeded with 100 kg seed ha-1 rather than a seed rate of 75, 125 and 150 kg ha-1. However, the current result is in contrast with Alemayehu (2015) [2] who reported that maximum grain yield recorded from a seed rate of 150 kg ha-1 and variety was not show significant effect on grain yield.

3. Summery and Conclusion
Wheat is one of the most important cereal crops globally and is a stable food about one third of the world population. It has been selected as one of the target crops in the strategic goal of attaining national food self- sufficiency, income generation, poverty alleviation and achieving socio-economic growth of the county. Wheat (*Tritium aestivum* L.) It is a major crop contributing importantly to the nutrient supply of the global population and has the highest content of protein of all the staple cereals and contains essential minerals, vitamins, and lipids. It shows wide adaptation to diverse agro-ecological conditions and cropping technologies. Seeding rate can impact on wheat tillering, grain yield and protein quality. Hence, achieving higher agronomic performance and better end-use quality requires optimizing and periodically reviewing management practices such as seeding rates.

At the highest seeding density, the increased intra-plant competition may have also contributed to the reduction in plant height. So optimum seed rat is recommend to enhance growth, yield component and yield of bread wheat production.

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