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Effects of Varying Seed Rates on Yield Performance of Winter Wheat Cultivars

(Panmure Research Station: A Case of Shamva District)

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Abstract: *A field experiment was conducted to study the effects of seed rates and variety on yield and yield components of winter wheat (Triticum aestivum. L) at Panmure Experiment Station, Shamva District during 2018 winter cropping season. Six levels of seed rates (60; 80; 100; 120; 140 and 160 kg ha-1) and three varieties (Dande, Kana and Ncema) were tested. The experiment was laid out as a randomized complete block design (RCBD) and was replicated three times. Phenological growth, yield and yield related data were collected and their ANOVA was analyzed using Cropstat version 7.0 and where treatment means were significantly different, they were separated using the Least Significant Difference (LSD) at 5% probability level. The results showed that using different seed rates on different varieties had significant effects. Only five parameters that include days to anthesis (flowering), days to physiological maturity, plant height, stem lodged plants and number of effective tillers per net plot had significant effect on different seed rates. However ear length and average tillers per plot had no significant effects to seed rates. The interaction of seed rates and varieties also showed no significant difference (p = 0.363) on grain yield. However, Kana had the highest yield of 2927.5 kg ha-1 and this was achieved at 32g/plot (80 kg ha-1) seed rate. There was significance (p < 0.01) interaction between variety and seed rates with regard to anthesis time. Dande was the first to reach anthesis at day 59, under seed rate of 40g/plot (110 kg ha-1) and 64g/plot (160 kg ha-1). There were significant (p < 0.01) interactive effects of variety and seed rate with regard to physiological maturity. Ncema variety elicited earliest maturity, reaching physiological maturity at day 116 after emergence and this was achieved under seed rate of 24g/ plot (60 kg ha-1) seed rate. However, further studies have to be done under different soils using higher seed rates more than 160 kg ha-1 and reducing the inter row spacing from 0.25m to 0.2m in order to exploit the recommendation of the present study.*

Keyword: *Experiment, effects of seed rates, variety on yield, yield components, winter wheat, varieties, Dande, Kana & Ncema.*

1. Introduction

Agriculture is the mainstay of the Zimbabwean economy providing livelihoods to approximately 70% of the population, contributing between 15% and 20% of Gross Domestic Product (GDP) and providing 40% of export earnings and supplying 63% of agro-industrial raw materials (Kapuya, Jongwe and Saruchera, 2010). This makes the agricultural sector strategic and very important sector in designing strategies and policies to reduce poverty, reduce food insecurity and boost rural incomes. Zimbabwe Central Statistical Office (ZIMSTAT) (2012), published a report on how wheat (*Triticum aestivum. L*) is the second most important strategic food security crop in Zimbabwe after maize. Wheat has become a staple crop given its high demand for bread and other confectioneries. Wheat farming is a major cropping activity and the commodity is highly valued particularly its product, bread. Bread has become a key staple food in Zimbabwe thus making wheat the second most important crop after maize, Kapuya *et al.* (2010). Wheat contributes about four percent to the GDP of Zimbabwe (Reserve Bank of Zimbabwe (RBZ), 2009). The immediate wheat products are flour and bran. Flour is the main ingredient for making bread and other confectionaries consumed daily by mostly urban Zimbabweans while wheat bran is mainly used in the stock feeds manufacturing sector.

Zimbabwe like most low-income countries has a high proportion of their population dependant on agriculture for their means of livelihood. Therefore what happens in the sector is critically important in determining economic development of the country. The farmers who are also the major consumers are doing well, this has a positive impact on the development of agro-processors and the demand for goods produced in the non-agriculture sector (Anseeus and Davies, 2011). This research will focus on the varying seed rates effects on yield performance across three spring wheat varieties namely Dande, Kana and Ncema at Panmure Experiment Station, Shamva district, Mashonaland central province in Zimbabwe. This research is trying to address the continued decline in wheat yield. There are so many reasons behind the decline in wheat yield and seed rate is one of the contributing agronomic factors. Optimum seeding rate is considered an important management factor for improving yield of any crop but this study mainly focuses on wheat. It is of particular importance in wheat production because it is under the farmer's control in most cropping systems (Hussain, Ali and Ahmad, 2012). Since cultivars genetically differ for yield components, individual cultivars need to be tested at a wide range of seeding rates to determine their optimum seeding rate (Wiersma, 2002). Previous research shows that seeding rates significantly affected biological yield, Hussain *et al.* (2012), spike number and weight (Ozturk, Caglar and Bulut, 2006). Higher seeding rates compensate for reduced tiller development and promote more main stem spikes which can be favourable, especially for cultivars that tend to produce fewer tillers (Gafaar, 2007); Rana, Ganga and Pachuri, 2005). A close relationship exists between wheat stands and yield components (Kumar, Singh and Thakur, 2011). According to Ozturk *et al.* (2006), too much competition, even among wheat plants, may lead to fewer grains per spike and lower grain weight. The key is to get an optimum plant population with uniform distribution for efficient use of available resources. This study was designed to provide a comprehensive understanding of the effects of varying seed rates on yield potential of selected varieties. Currently, there is lack of detailed and consolidated information in the Shamva area concerning the optimum seed rates for the winter varieties.

2. Methodology

2.1 Research site

The study was conducted at Panmure Experiment Station in Shamva and is 95 km from Harare on the North Eastern side at a 1ongitude 31^{o}47’E and latitude 17^{o}16’S. The altitude is 881 metres above sea level (m.a.s.l). The area falls under natural region IIB with an average rainfall of between 700-900 mm annually, mean maximum temperature of 30^{o}C and mean minimum of 15^{o}C with ground temperature reaching about -15^{o}C with soils predominantly reddish brown, medium grained loamy and sandy loams prone to capping problems.

2.2 Plant varieties

Three wheat cultivars (Dande, Ncema and Kana) were used (Table 3.1). The three wheat cultivars were medium maturing varieties which have nearly similar days to reach physiological maturity and yield potential. The normal statured Dande variety has a yield potential of 2.8 t/ha and matures in 125 - 130 days. Ncema variety has a yield potential of 2.5 t/ha and matures between 125 and 130 days and Kana has yield potential of 3t/ha maturing between 115 and 125 days.

Table 1: Germplasm used and their sources

Germplasm	Growth habit	Potential height	Source
Dande	normal stature	0.90	Crop Breeding Institute
Ncema	normal stature	0.75	Crop Breeding Institute
Kana	normal stature	0.80	Crop Breeding Institute

2.3 Experimental design

The experimental design was randomized complete block design (RCBD), replicated three times. Three wheat varieties namely Dande, Kana and Ncema were assigned to the main plots with six treatments or six seed rates levels per each cultivar, (Appendix 11).

Table 2. Allocation of treatments

Treatment	Seed rate per plot (3.5m^2)	Seed rate per hectare
1	24 g	60kg/ha
2	32 g	80kg/ha
3	40 g	100kg/ha
4	48 g	120kg/ha
5	56 g	140kg/ha
6	64 g	160kg/ha

2.4 Land Preparation

The land was prepared using a tractor drawn disk plough in early April 2018. Secondary tillage operations such as discing and rolling were carried out in order to produce a fine tilth and to get rid of early weeds and levelling off the field plots to avoid bias. Maize was the previous crop planted on that block.

2.5 Planting

Wheat was planted by on the 5th of May 2018; planting was done using the drilling method in rows spaced 25 cm apart. Seed was drilled by hand and covered with a thin layer of soil. Furrows were opened using a hoe. The rows were at 0,25m inter row spacing and seed planted at a specified seed rate per hectare according to the treatment. The planting depth was 3-5cm using the drilling method. The distance between plots along the rows was 0.5m. The distance from one replicate to the other was 1m. Each replicate had 18 plots and total plots were 54, whereby each gross plot had an area measurement of 3.5m^2(8 rows). Gross plot size was 8 rows, 1.75m width and 2 m row length.

2.6 Fertilization

Fertilizer rates of 400kg/ha Compound D at 7-14-7 (0.53 - 1.06 - 0.53) NPK kg/ trial area and drilled in the rows at uniform rate. Fertilizer was drilled by hand in the furrows and stirred to mix with soil to avoid seed scorch by the 7% N in compound D Top dressing was applied at 400kg/ha Ammonium Nitrate (AN) 34.5% (2.61 kg/trial) was split applied after irrigations in equal amount. The first split of ammonium (AN) was applied at six weeks after the time of emergence and second split was applied four weeks later.

2.7 Irrigation management

The crop was subsequently irrigated as per need of the crop and soil during growth and development. All irrigation cycles were applied at uniform rate for all the treatments. The crop was subsequently irrigated as per need of the crop and soil during growth and development. From first irrigation to plant physiological maturity, 10 irrigation cycles were applied at total irrigation was 524.7mm.

2.8 Weeds Control

Mainly broad leaved weeds like gallant soldier (*Gallinsoga parviflora*) and black jack (*Bidens pilosa*) were found and these were controlled by an herbicide called 2-Methyl-4 Chlorophenoxyacetic Acid (MCPA) for reducing weed-crop competition once before the canopy closure. At a later stage weeds were controlled manually using hoes and hand pulling.

2.9 Pests Control

Leaf eaters were the first pests to be observed feeding on wheat leaves at 4 weeks after crop emergency (WACE). These pests did not inflict much damage to the photosynthetic machinery of wheat. A formulation of Carbaryl 40 wetable powder (WP) was applied at the rate of 1 kg/ha to control the leaf eaters.

2.10 Diseases Control

Wheat rust was visually assessed and scored where all three varieties had less than five percent that means they were tolerant to the disease. Therefore no disease control which was done.

2.11 Data collection

Data was collected using different parameters as discussed in the sections below.

2.12 Phenological parameters

Days to 50% flowering (anthesis)

Anthesis was recorded when the ears or panicles where small, white flowers were fully visible or produced pollen tubes. The plants reaching 50% flowering from each plot were determined by visual observation and recorded.

Days to 90% physiological maturity

Days to physiological maturity were recorded by counting the number of days from day of emergence until when 90% of the plants changed from green colour to yellowish, for which it had lost its water content due to physiological maturity.

2.13 Vegetative growth parameters

Plant height (cm)

The average height of ten randomly selected plants from the net plot area of each plot was measured in centimetres from the ground to the top of spike, excluding awns at maturity. The means were recorded.

Effective Tiller Numbers

The numbers of effective (fertile) tillers per $1m^2$ were counted from each plot at harvesting.

Number of lodged plants per net plot

Total number of lodged plants per net plot were counted and recorded at harvesting.

2.14 Yield and yield related parameters

Ear length (cm)

Ear length was measured from ten randomly selected plants of the inner rows in centimetres and the mean length was recorded on each plot by measuring from the base to the upper most part of the spike.

Average number of ears per plant

Numbers of productive ears per plant were counted from ten randomly selected plants from the inner rows of each plot and the mean ear number was recorded.

Total number of tillers per net plot

The total numbers of productive spikes per net plot were counted at harvesting.

Grain yield (kg)

Grain yield was measured by taking the weight of the grains threshed from the net plot area of each plot and converted to kilograms.

Moisture content (%)

Grain moisture was measured by taking the moisture of the grains threshed from the net plot area of each plot in percentage.

Harvesting

Harvesting was done on the 10^{th} of October 2018. A net plot of four rows (middle) measuring $2m^2$ was harvested, after discarding two rows on either side. It was carried out sequentially, beginning with plot one up to the last plot number (54). Sickles were used to cut the above ground biomass of wheat ears and put into harvesting bags.

Grain processing

Each harvested plot was threshed and winnowed at the sheds, then weighing of grain was done using digital scale and lastly taking moisture of each sample using a moisture meter. All the data was recorded for each process done.

2.15 Data presentation

The data was presented using bar graphs on grain yield, plant height and tillers per plant. Line graphs were used to interpret the data for days to physiological maturity, anthesis and stem lodging.

2.16 Statistical Analysis

Data was analysed using Cropstat version 7.0 and where treatment means were significantly different; they were separated using the Least Significant Difference (LSD) at 5% probability level.

3. Results and Discussion

3.1 Grain yield

Wheat variety and seed rate treatments had no combined effect ($p = 0.363$) on grain yield (Figure 1). However, significant ($p < 0.01$) effects were recorded on the main parameters of variety which include plant height, anthesis, stem lodging, days to physiological maturity and tillers per plant. Seed rate main effect was not significant ($p < 0.061$). Kana had the highest yield of 2927.5 kg $ha^{-1}$and this was achieved at a seed rate of 32g/plot. This current result differs with those of Hameed *et al.* (2003) and Ijaz *et al*. (2002), who reported that grain yield increased as seed rate increased. The interaction of seed rate and ear length was not statistically significant. There is contrast on findings from Hussain *et al*. (2012) and Awdie, Singh and McCaig (2008) reported that grain yield increased as seeding rate was increased from 50 to 150 kg ha^{-1} and from 100 to 150 kg ha^{-1}, respectively. Moreover, Ali *et al*. (2010) concluded that the three years average data showed that grain yield was higher at seeding rate of 150 kg ha^{-1} followed by 175 and 200 kg ha^{-1} as against the seeding rate of 125 kg ha^{-1}.

The same result was also reported by Iqbal *et al*. (2010) who concluded that seeding rate of 150 kg ha^{-1} produced significantly higher grain yield (4120 kg ha^{-1}) followed by 175 and 200 kg ha^{-1} seeding rates (3904 and 3785 kg ha^{-1}). However, seeding rate of 125 kg produced significantly lower grain yield (3.669 t). Report by Nazir *et al.* (2000) also showed that 150 kg ha^{-1} seeding rate produced significantly the highest grain yield. Likewise, Jemal *et al.* (2015) also reported that Shorima and Kakaba varieties gave maximum grain yield at seeding rate of 150 kg ha^{-1} and Digalu variety produced highest yield at seeding rate of 175 kg ha^{-1} as compared to 100; 125; and 200kg ha^{-1}. Seleiman *et al.* (2010) also confirmed that increasing seeding rates up to350 or 400 grains m^{-2} increased grain yield. Higher grain yield with higher seeding rates was also reported by Olsen *et al*. (2005); Haile and Girma, (2010). The same result was also confirmed by Sikander *et al.* (2003) who concluded that increasing seeding rate from 150 - 250 seeds/m^2 resulted in higher grain yield.

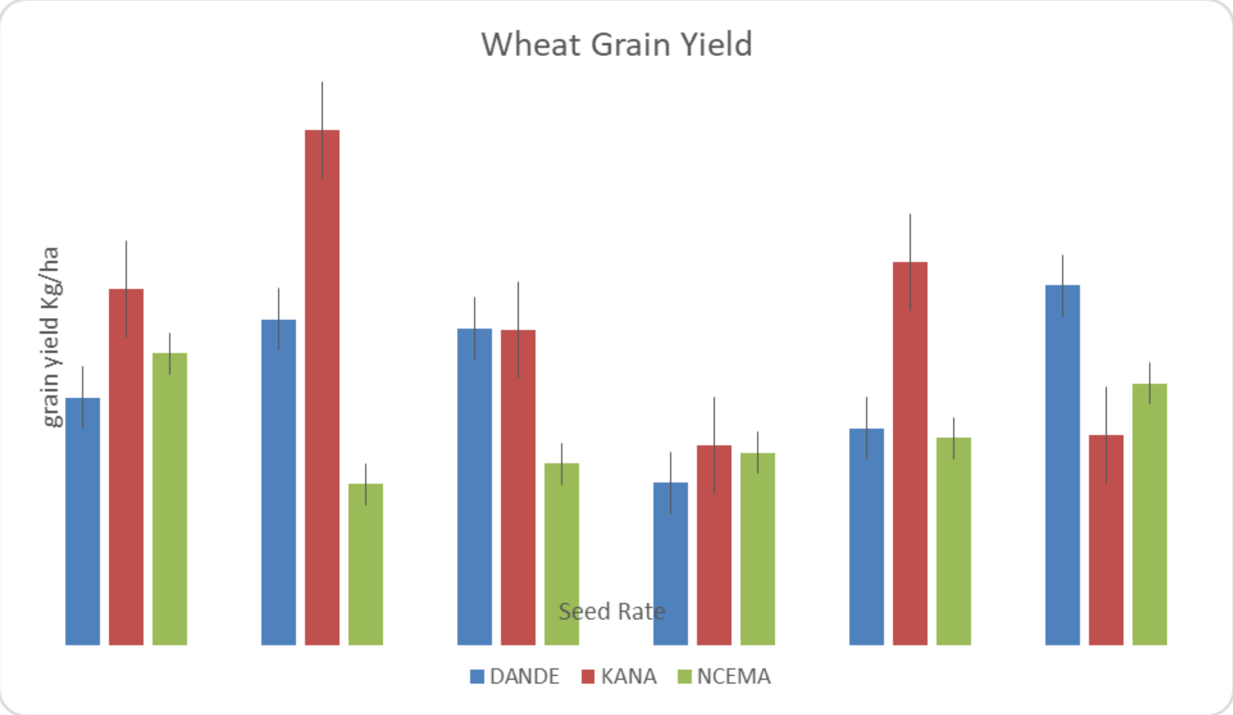


Figure 1: Effects of Seed rate on yield of wheat varieties.
Vertical bars represent standard error bars of means

3.2 Days to anthesis

There was a significant ($p < 0.01$) interaction between variety and seed rate with regard to anthesis time. Dande was the first one to reach anthesis at day 59, under 40g (100 kg ha^{-1}) and 64g (160 kg ha^{-1}) seed rate. Ncema was the last flowering variety, reaching anthesis at 67 days under 24g (60 kg ha^{-1}) seed rate (Figure 2). Kana exhibited intermediate performance, with an average of 62 days to anthesis across all seed rates. As the seed rates increased across all varieties (Dande, Kana and Ncema), the days to anthesis were decreasing. This was due to high competition for sunlight, nutrients and moisture between plants which accelerated to the days to flowering. It is critical to match variety and sowing time to ensure flowering occurs during the optimal flowering window to maximise grain yield potential. This finding was also confirmed by Gafaar (2007) who indicated that increasing sowing density from 200 up to 400 grains per meter square in wheat crop significantly decreased the number of days to 50% flowering. Another research finding on the effect of seeding rate also revealed the same results of flowering being affected by higher seeding rates (Iqbal *et al*. 2010). Furthermore, Awdie *et al.* (2008) concluded that increasing the levels of seeding rates decreased the days to flowering consistently.

The optimum flowering window is determined by a balance in water used during canopy development and water used during the grain formation and grain-filling phases (Hussain, Ali and Ahmed, 2012). Crops that flower too early have increased risk of frost damage, while crops which flower too late have increased risk of high temperatures and water deficit which can restrict grain formation and grain-filling. In vernalisation, there is a responsive within varieties following saturation of long days where there is hasten progressive inflorescence development and stem elongation. Vernalisation is essentially the prerequisite for long days to reduce the time to flowering (Bryan, 2011). According to Park *et al*. (2003), Optimum seeding rates for grain yield of winter cereals may be higher when seeding is delayed past the optimum date of seeding. Higher seeding rates increase early days to maturity and weed competitiveness, but may have negligible or negative impacts on grain yield due to increased interplant competition.

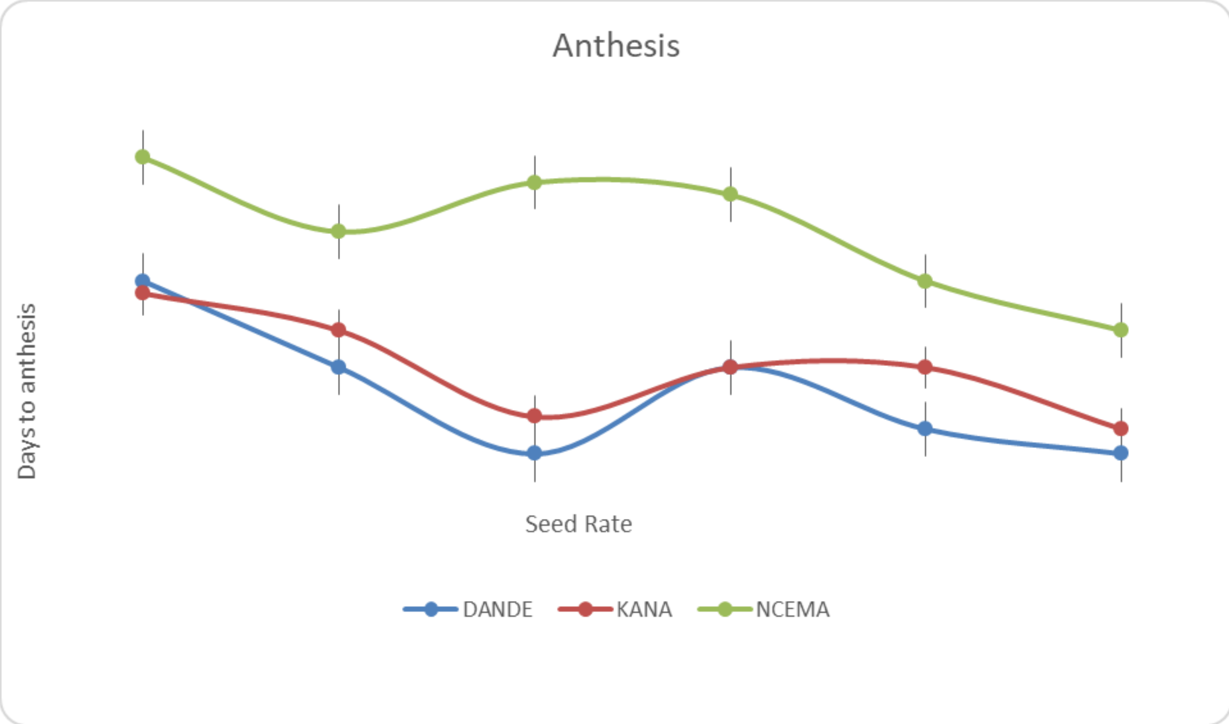


Figure 2: Interactive effects of variety and seed rate on days to anthesis

3.3 Days to physiological maturity

Days to 90% physiological maturity showed significant ($p < 0.01$) interaction effects of variety and seed rate in relation to physiological maturity. Ncema variety elicited earliest maturity, reaching physiological maturity at day 116 after emergence and this was achieved under 24g (60 kg ha^{-1}) seed rate. Dande recorded relatively late maturity, reaching physiological maturity at day 129 at 24g (60 kg ha^{-1}) after emergence (Figure 3). Increasing seeding rate from 24g (60 kg ha^{-1}) to 64g (160 kg ha^{-1}) decreased days to 90% maturity on Dande and Kana. The highest seeding rates on these two varieties associated with early maturity might be due to plant competition for available resources that include moisture, sunlight and nutrients. The result was in agreement with Seleiman *et al*. (2010) who reported that increasing seeding rates from 250 - 400 m^{-2} grains prolong the number of days from sowing to maturity of wheat. The present finding showed that as seeding rate decreases from 64g to 24g/plot, days to physiological maturity increased from 121 to 129 days (Figure 3). Similar with the present finding by Awdie *et al*. (2008) also noted that increasing the levels of seeding rate hastened physiological maturity of bread wheat. Furthermore, Bryan (2011) indicated that increasing levels of seeding rate promoted early physiological maturity on different cultivars of wheat. In conformity with the present result by Hassanein (2014) reported that, differences in maturity can be caused by the combined effect of genetic and environmental factors during their growth and grain filling of the crops. However the result was in contrast with the findings from Osman and Mohamed (2011) who reported that abundant supply of seed rates delay physiological maturity in wheat. This is due to luxurious growth at the expense of flowering where there is ranky growth; plants compete for nutrients and sunlight.

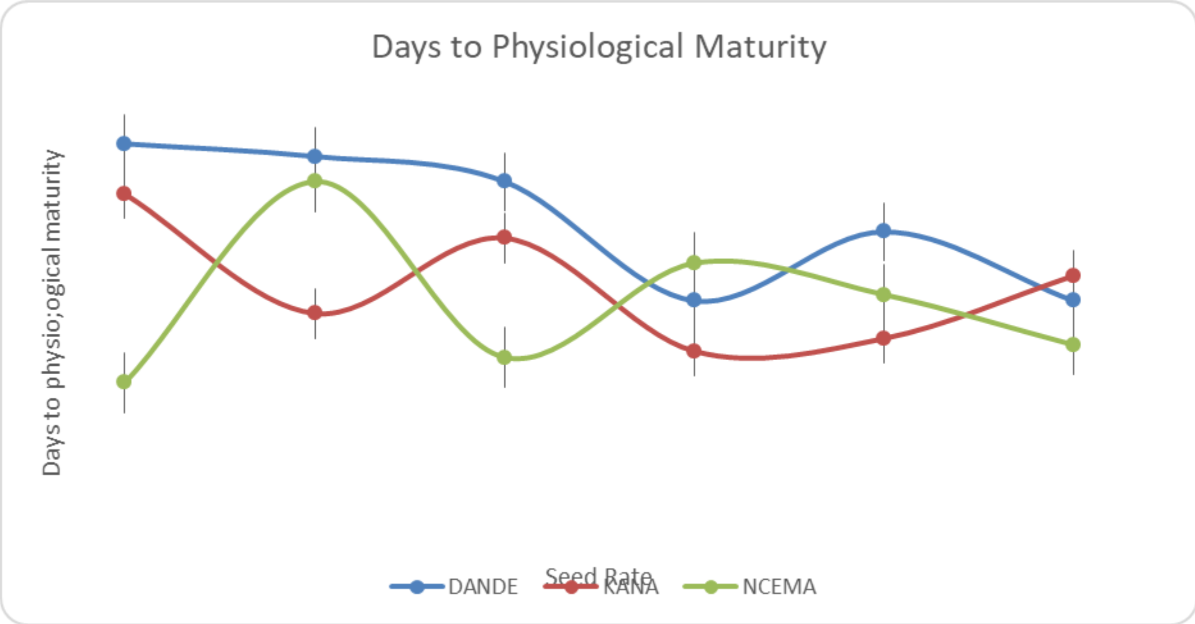


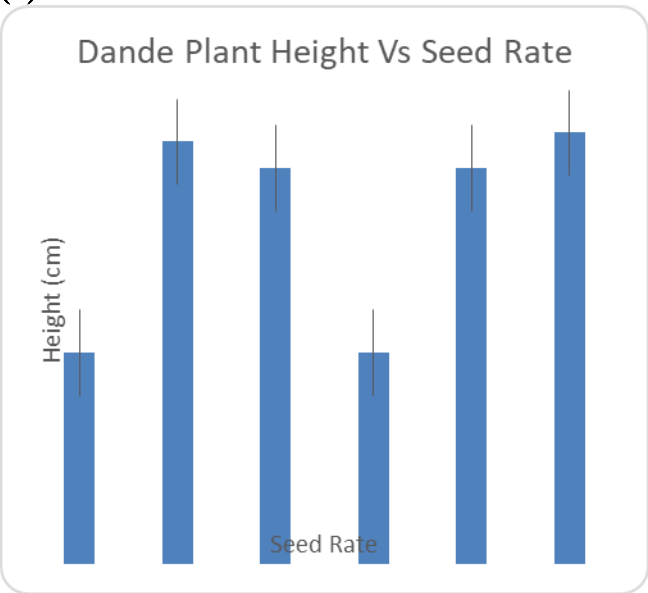
Figure 3 Interactive effects of variety and seed rate of plant physioloogical maturity.

3.4 Plant height (cm)

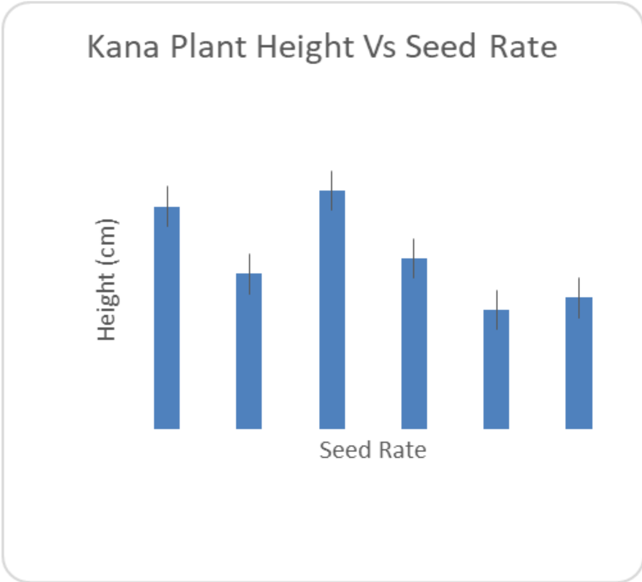
The analysis of variance indicated that the main effects of variety were not significant ($p > 0.08$) to the plant height; however in contrast, the seed rates were significant ($p < 0.01$) to the plant height (Figure 4). Kana scored the greatest height of 90 cm under 40g seed rate. Ncema was the shortest, with 72 cm under 32g (80 kg ha^{-1}) seed rate (Figure 4 c). Overally, Kana had the highest average plant height across all seed rates (84.5 cm). Similar with the present finding, Soomro *et al.* (2009) noted that wheat sown at higher seeding rate produced greater plant height as shown by Dande at 56g/plot, followed by 64g/plot, but their findings differed with Ncema and Kana across all seed rates. Another research finding by Awdie *et al.* (2008) also concluded that plant height increased consistently with increasing seeding rate. Rahim *et al.* (2012) also reported that the significant difference on plant densities of 450 and 300 plants m^2 with highest and lowest plant height, respectively. Other researchers also reported in wheat that the height of plants grown at the lowest seeding rate was significantly lower than the height of plants grown at higher seeding rates (Spink *et al*. 2014; Ghulam *et al.* 2011).

Moreover, this result was in harmony with the finding of Fani *et al*. (2014) who indicated that with increasing density, plant height slightly increases and there after decreases could be attributed to restrictions on plant food sources. Height of the crop is mainly controlled by the genetic makeup of a genotype and it can also be affected by the environmental factors (Mennan and Zandstra, 2005).

(a) - Dande



(b) - Kana



(c)Ncema

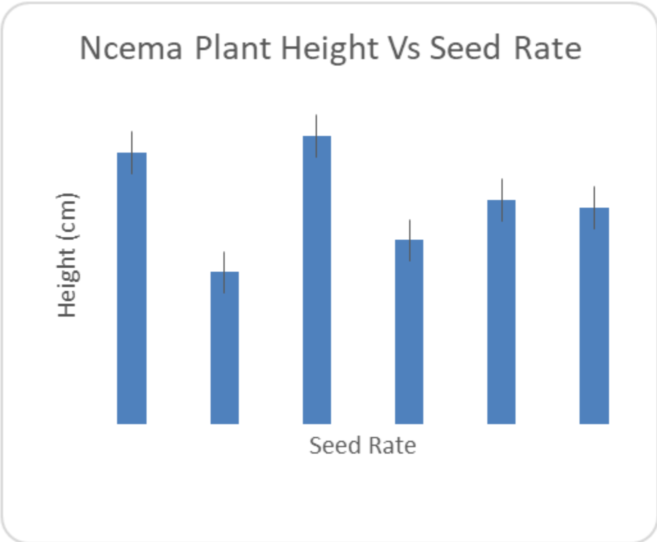


Figure 4: Main effects of seed rate on plant height of varieties- a) Dande; b) Kana and c) Ncema.

Stem lodging

There was significant ($p < 0.01$) interaction between seed rate and variety, however the main effects of seed rate and variety were not significant ($p = 0.786$; $p = 0.122$, respectively). Highest lodging for every variety was recorded under 64g seed rate (Figure 5). Lodging was zero under 24g seed rate for all varieties. The current findings have highlighted that stem lodging increases with an increase in the seed rate. These results are congruent with findings observed by Monsanto (2015) in soyabean. Higher seeding rate caused lodging due to stem thickness because of the lower light penetrating into the plants canopy bed and more inter specific competition to more absorption light. Higher seeding rate and lower light penetration influences increase of inter node length, reducing stem thickness and increasing plant height (Otteson *et al*. 2007). Increasing seed rate results in increased plant populations hence plants are prone to compete for resources and there is high likelihood of stunted growth and weak stems.

According to Spink *et al*. (2014), winter wheat is capable of compensating among yield components, which often results in similar grain yields being produced across a fairly wide range of seeding rates. However, using seeding rates that are too low can lead to excessive tillering. This may also delay maturity, increase weed competition, and fail to make use of the plant's full yield potential. Using rates that are too high may increase costs, result in increased lodging, and possibly reduce yields.

Too much competition, even among small grain plants, may lead to fewer kernels per head and lower kernel weight. The key is to get an optimum plant population with uniform distribution for efficient use of available resources.

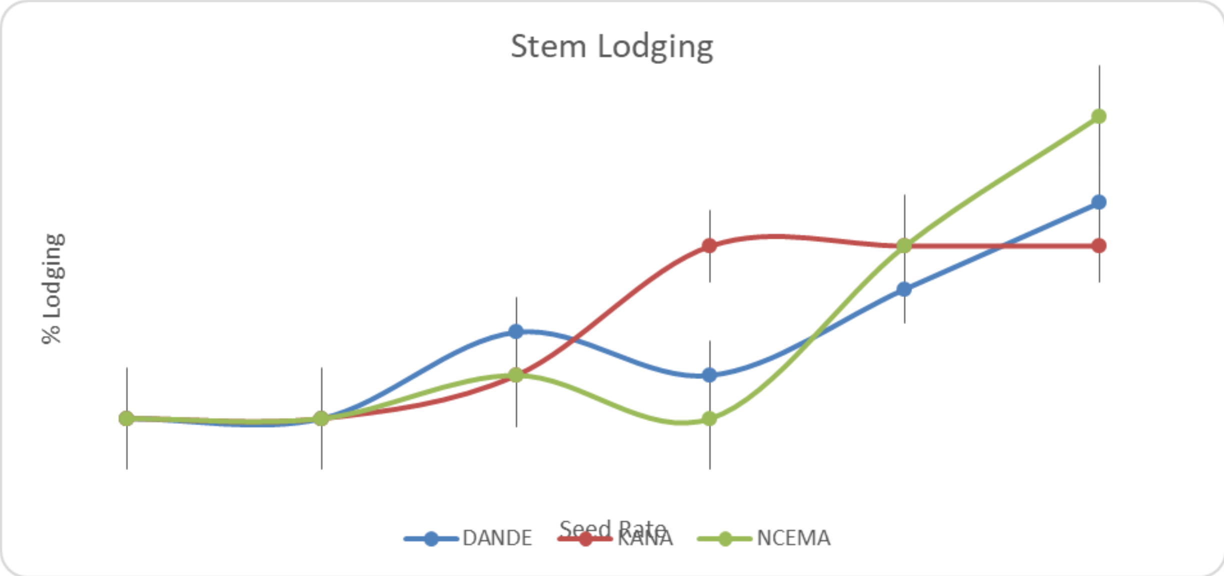


Figure 5: Interactive effects of seed rate and variety on stem lodging

3.5 Average number of tillers per plant

There were no significant (p =0.015) differences in tillers per plant attributed to the main effect of seed rate. There were no significant interaction and variety main effect in tillers per plant (p = 0.54; p = 0.784). Dande scored the highest number of tillers per plant (38), however Kana recorded the highest average tillers of 27 across all seed rates. The current result from Kana and Ncema is not in agreement with those of Ali *et al*. (2010) who reported that the number of effective tillers increased as seeding rate increased. Similarly the findings is in contrast with Abd- El-Lattief (2011), who also concluded that the highest number of effective tillers was obtained at 200 kg ha^{-1} seeding rate while, the lowest number of effective tillers per 0.5 m row length (25.66) was obtained at 100 kg ha^{-1} seeding rate. Such increase in number of effective tillers might be due to increasing sowing density that could be attributed to increasing number of plants per plot and also tillering capacity.

The present finding is also in contrast with Iqbal *et al.* (2010) who stated that more number of tillers (503.40) was observed at seeding rate of 175 kg ha^{-1} while less number of tillers (404.40) was recorded at seeding rate of 125 kg ha^{-1} and was statistically less (464.6) from seeding rate of 150 kg ha^{-1}. Increase in number of tillers per unit area might be due to increased seeding rate (Ahmad *et al.* 2003; Khan *et al.* 2002; Hussain *et al.* (2012); Naeem, 2001; Otteson *et al*. 2007). Another research finding by Iqbal *et al*. (2010) also stated that there was linear increase in number of fertile tillers with increased seeding rate and among seeding rates, 200 kg ha^{-1} produced significantly higher number of fertile tillers (278.75) followed by 175 kg ha^{-1} seeding rate (263.97 fertile tillers). The present result where Ncema produced 14 tillers per plant at 80kg ha^{-1}; 18 tillers per plant at 100kg ha^{-1}and 23tillers per plant at 120kg ha^{-1} was in harmony with Chaudhary *et al.* (2010); Arif *et al*. (2003) and Ali *et al.* (2010) who reported increased tillering with increased in seeding rate. Moreover, Rafique *et al.* (1997) also reported the linear increase in the number of tillers as the seeding rate was increased. Similarly, this result concurs with Abd El- Lattief (2011), who found that as the seeding rate increased from 100 kg ha^{-1} to 175 kg ha^{-1}, number of effective tillers also increased from 303.3 to 348.7 m^{-2}. Kumar *et al.* (2011) and Ahmad *et al.* (2003) confirmed the present result who reported that higher sowing rates increased the number of tillers m^{-2}. Likewise, Seleiman *et al*. (2010) stated that increasing seeding rate up to 350 or 400 grains m^{-2} increased the number of tillers per m^{-2} but significantly decreased grain filling rate.

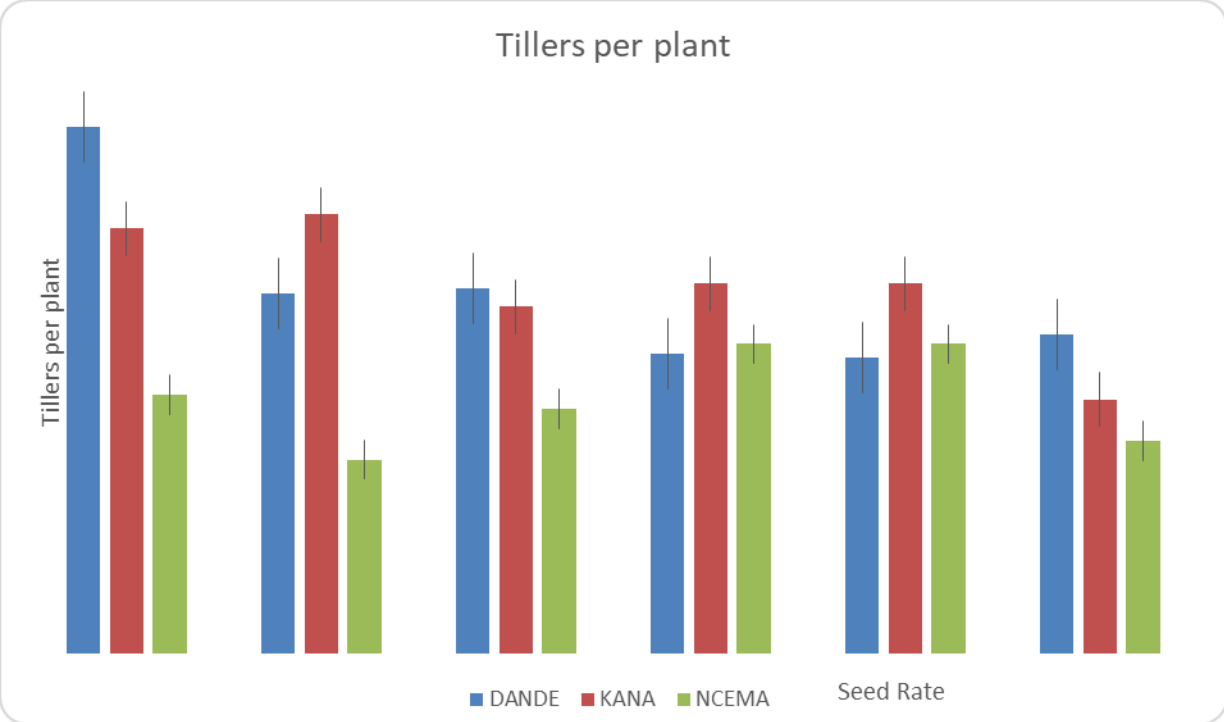


Figure 6: Main effect of seed rate on tillering

3.6 Ear length (cm)

Ear length of wheat at harvest was not affected by varieties and seed rate. There was no significant interaction ($p<0.260$). This result was in contrast with that of Otteson *et al*. (2007) who reported that individual genotypes responded differently to spike length for varying seeding rates in wheat. The result was in agreement with Araus *et al*. (2007) who reported reduced spike length, fewer spikelet per spike and kernels per spikelet of triticale with increased seeding rate or plant density.

4. Conclusion

The results showed that using of different seed rates had no significant effect on grain yield except on one variety which is Dande; however seed rate had significance on plant height, number of tiller per plot, lodged plants, days to anthesis and days to physiological maturity. The interaction of seed rate and ear length and average tillers per plant did not show any significant difference. The yield potential of Kana had the highest yield of 2927.5 kg ha^{-1} achieved at a seed rate of 32g/plot is extremely exciting but it is important that seeding rates are kept low in sandy soils or lodging could become a serious problem. As wheat planting gets delayed later into the year seeding rates should be increased to account for the reduced time the plant has for tillering. From the present study it is possible to conclude that both seeding rate and variety affect most of yield and yield related traits of wheat. The results of the data indicated significant differences ($p < 0.05$) in all agronomic traits such as days to anthesis ($p < 0.001$), days to physiological maturity ($p < 0.001$) and stem lodging ($p < 0.001$). There was no combined significance interaction between seed rates and variety on plant height ($p = 0.341$), ear count ($p =0.221$), average tillers per plant ($p =0.540$), ear length ($p = 0.260$) and grain yield (p =363) to emergence in response to the different seeding rates.

The result of this study on six seeding rates proved that the use of 80 kg ha^{-1} on Kana is superior in wheat agronomic traits such as grain yield. Therefore, this study investigated and concluded that seeding rate of 80 kg ha^{-1} performed better and gave higher grain yield (2927.5 kg ha^{-1}) and has potential grain yield advantage of 140 kg ha $^{-1}$. However Dande had the highest tillers per plant (38) at seeding rate of (60 kg ha^{-1}) even though the lowest seeding rates were not advantageous in many of yield and yield component traits. The results of the data also indicated significant variations of seed rate ($p < 0.001$) on days to physiological maturity. Ncema variety reached physiological maturity late than any other varieties, 129 days at 24g (60 kg ha^{-1}) after emergence.

7. Recommendations

a. Small holder farmers are urged to adopt seed rates of 80 kg ha^{-1} and 140 kg ha^{-1} for Kana where it produced an average wheat grain yield of (2927.5 kg ha^{-1}; 2300 kg ha^{-1}) respectively in reddish brown loamy soils.
b. Dande provided better yield of 2200 kg ha^{-1} at a seed rate of 160 kg ha^{-1}, therefore smallholder farmers are advised to use this seed rate in reddish brown loamy soils.
c. Ncema did not perform well across all the seed rates under reddish brown loamy soils; therefore it is recommended to grow it in other soil types.
d. There is need for further research studies using higher seed rates and reducing the inter row spacing from 0.25m to 0.2m.
e. However, to make reliable and acceptable recommendation it is better to repeat this experiment across different locations and over seasons on different type of soils.

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