Effects of drilling and dibbing planting techniques on yield and yield components in Wheat (*Triticum aestivum* L.)

ABSTRACT

The current study was conducted in the 2017–2018 Rabi seasons at the Wheat Research Unit's research farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, to assess the effects of drilling and dibbling, the planting techniques of planting on yield components, and consequently, on the yield of the Wheat varieties being studied. This is because drilling and dibbling, as opposed to the conventional way of sowing, assure a uniform distribution of seeds at the right depth, which improves germination, maximizes plant spacing, and ultimately increases agricultural yields. The Factorial Randomized Block design (FRBD) experiment was triple-replicated and employed ten treatments. Varieties V1 (AKAW 4210-6) and V2 (AKAW 4627) were the initial factors. While S1 (drilling at 20 cm @ 100 kg ha^{-1}), S2 (drilling at 20 cm @ 50 kg ha^{-1}), S3 (dibbling at 15 x 15 cm), S4 (dibbling at 15 x 20 cm), and S5 (dibbling at 20 x 20 cm) were the five distinct sowing procedures utilized in the treatments. The sowing method of S5 (dibbling at 20 x 20 cm) was found to have significantly higher yield attributes, including number of spikes $plant^{-1}$, length of spike (cm), number of grains $spike^{-1}$, weight of spike (g), straw yield $plant^{-1}$(g), test weight(g), number of grains $plant^{-1}$, straw yield $plant^{-1}$(kg ha^{-1}), biological yield (q ha^{-1}), test weight(g), and grain yield $plant^{-1}$ (q ha^{-1}). S3 (dibbling at 15 x 15 cm) and S4 (dibbling at 15 x 20 cm) were the next two methods. When compared to the drilling method of planting, the dibbling method of sowing at a spacing of 20 x 20 cm may have contributed to an improvement in grain production of almost by 10 percent since it greatly boosted the yield-forming components in the experiment,

Key Words: Planting methods, dibbling, drilling, yield, yield components, wheat grains

INTRODUCTION

The most significant food grain in the world is wheat (*Triticum aestivum* L.). The most notable aspect of wheat cultivation is its role in the expansion of human might as a land-mass colonizer. Worldwide, wheat cultivation takes up more land than any other crop. Around the world, wheat is a major staple crop. Compared to food derived from other cereal grains, it supplies a vast quantity of the world's nutrition in its many dietary forms.

In underdeveloped nations, wheat accounts for up to 60% of daily caloric intake and 28% of the world's edible dry matter (Cakmak, 2008). By 2050, food consumption is predicted to double in addition to the rising need for nutritious, high-quality food. It is also anticipated that the demand for wheat products will rise quickly on a global scale. Human health and well-being are greatly impacted by the nutritional excellence and content of wheat, particularly in developing nations. Therefore, more attention needs to be paid to issues that affect both wheat yield and quality (Wang et al. 2011). Wheat provides 20% of the calories consumed by humans. Wheat's nutritional value is on par with that of other important grains. Its protein level is higher than that of other grains. Wheat contains comparatively high levels of thiamine and niacin, two nutrients that are very significant (Khichar and Nivas, 2007). Wheat's agronomic and end-use excellent qualities are impacted by seed rate, a conservative management factor. In order to get greater grain yields with improved end-user excellence, it should be thoroughly researched. According to earlier research, a dense population of wheat caused plant competition, which in turn led to self-regulation (Costa et al. 2015). By creating suitable population patterns, optimum planting density can regulate intraspecific competition between individuals and populations. During crop growth, environmental resources including light, water, and nutrients are strongly influenced by seed rate. According to Chengappa et al. (2007), a high seed rate results in increased water consumption prior to anthesis, which lowers grain yield and grain per spike. Unproductive crops can be the result of improper sowing methods. The smaller ears and overall size, along with the greater susceptibility to lodging, pests, and diseases, led to a drop in the crop's production per unit area, according to Bakht et al. (2011). Dibbling is one of the sowing methods that performs best in soil that is suited for it. This method involves planting a seed in a shallow hole and covering it with nearby soil (Rehman et al., 1993). A very efficient approach to use solar energy for drought-tolerant seeding is the dibbling method. It is usually used in places where plowing and harrowing are difficult. Since dibbling is done by hand, it is believed to take longer than drilling and other conventional sowing methods, and it is mostly used by small-scale farmers (Luo et al., 2016). It is advised to seed via drilling because of its steady population per unit area.

According to Tanveer et al. (2003), when seeds are sown at a constant depth and covered with soil, robust germination and uniform stands are expected. In recent years, the new, extremely accurate planting pattern has become more and more popular. This new broad precision sowing planting pattern separates the individual grains from each other, as opposed to drilling and dibbling, which plants all the seeds in a line (Dandan et al., 2013; Bian et al., 2016). Thus, the only option to transition from subsistence to commercial farming is to employ efficient and effective technologies (Anonymous, 2016). The real benefit of mechanical broadcasting over traditional (manual) broadcasting is the regularity with which the designated quantity of seed is distributed throughout the area. The real benefit of drilled crops, particularly for wheat, is a 15% boost in yield, claim Tahir et al. (2009). When compared to traditional soil preparation techniques, the yield of wheat sown with this method is 15% higher. Crucially, crops that are sown widely apart sometimes mature more slowly than a dense population. To give farmers a favorable yield, it is important to consider not only the optimal seed rate but also suitable sowing methods (Mollah et al. 2009). The availability of resources such as sunlight, moisture, and nutrients is increased by using the right seeding techniques. Once more, from the start of crop growth, accessibility encourages the proper growth and establishment of the root system. Sowing techniques guarantee optimal crop establishment and the most advantageous plant population in the field, while also enabling plants to employ the available area and other resources more decisively and efficiently toward growth and development (Singh and Sharma, 2019). Accordingly, a study was carried out to investigate how the drilling and dibbling techniques of seeding affected the yield components of various wheat varieties and, eventually, their yield.

MATERIALS AND METHODS

2.1. Experimental Site

The current study was conducted at the Wheat Research Unit's experimental farm, Dr. Punjabrao Deshmukh Krishi Vidyapeeth, in Akola, Maharashtra, India, during the Rabi season of 2017–2018.

2.2. Preparatory tillage operation

Following the harvest of the soybean crop, the experimental area was harrowed twice and thoroughly ploughed using a mold board plough. This enhanced crop emergence and plant stand by making it simpler to prepare the seed beds in the assigned plots and plant the seeds.

2.3. Manures and fertilizers application

During field preparation, 5 t ha^{-1} of farm yard manure was applied to the field in a treatment-wise fashion. The crop was treated with nitrogen, phosphate, and potassium in accordance with the required fertilizer dosage (120:60:40 N, P_2O_5, and K_2O kg ha^{-1}, respectively). Murate of potash was used for potassium, single super phosphate for phosphorus, and urea for nitrogen. Half of the nitrogen was administered at the time of sowing, and the other half was applied as a top dressing 30 days after emergence. Both doses were equivalent. At the time of seeding, a complete dose of phosphate and potash was given to each unit plot.

2.4. Experimental materials, sowing and design

The seeds of the wheat varieties AKAW 4210-6 and AKAW 4627 were supplied for use as experimental material by the Wheat Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The initial factors are varieties V1 (AKAW 4210-6) and V2 (AKAW 4627). The five different sowing techniques used in the treatments were S1 (drilling at 20 cm @ 100 kg ha^{-1}), S2 (drilling at 20 cm @ 50 kg ha^{-1}), S3 (dibbling at 15 x 15 cm), S4 (dibbling at 15 x 20 cm), and S5 (dibbling at 20 x 20 cm). At varying seed rates (i.e., 100 kg ha^{-1} and 50 kg ha^{-1}), the seeds were drilled 20 cm apart between rows. Furthermore, seeds (particularly 15 x 15 cm (4,44,444), 15 x 20 cm (3,33,333), and 20 x 20 cm (2,50,000) were dubbed at various plant populations and spacing levels. Ten treatments were used in the triple-replicated Factorial Randomized Block design (FRBD) experiment.

2.5. Soil Characteristics

To ascertain the physico-chemical properties of the soil, soil samples were taken from 0 to 30 cm depth at representative designated locations randomly selected across the experimental area prior to the crop being seeded. The composite samples were then made by carefully mixing the dirt. In order to smash the aggregate particles without affecting the final soil sample particles, the samples were ground with a mortar and pestle and allowed to air dry. It was packed in canvas bags, labeled correctly, and sieved using a 2 mm sieve. It was then used to examine the physico-chemical properties of the soils in the experimental plot.

Table 1: Physico-chemical properties of soils of experimental plot.

Sr. No.	Particulars	Value before sowing	Value after harvest	Analytical method adopted
A.	**Mechanical composition**			
1.	Clay (%)	59.30	59.30	Bouyoucos Hydrometer method (Piper, 1966)
2.	Silt (%)	29.50	29.50	
3.	Sand (%)	11.20	11.20	
4.	Textural Class	Clay	Clay	Textural Triangle
B.	**Chemical composition**			
1.	Available Nitrogen (kg ha^{-1})	228.32	204.52	Alkaline permanganate method (Subbaih and Asija,1956)
2.	Available phosphorus (kg ha^{-1})	24.80	12.38	Olsen's method (Jackson, 1967)
3.	Available potassium (kg ha^{-1})	369.19	343.59	Flame photometer(Jackson, 1967)
4.	Organic carbon (g kg^{-1})	6.9	4.8	Walkley and Black method (Jackson ,1967)
C.	**Soil Reaction**			
1.	Soil pH	7.48	7.36	Beckman's glass electrode pH meter (Jackson,1967)
2.	Electrical conductivity (dSm^{-1})	0.256	0.242	Electric conductivity bridge (Jackson, 1967)

2.6. Observations Collected

Five plants were randomly selected from each unit plot for each treatment in each replication in order to record the various observations. The details of the observations that were made and their frequency are listed in Table 2.

Table 2: Details of biometric observations recorded during course of Investigation.

Sr.No.	Particulars	Frequency	At harvest
A)	**Post –harvest**		
1	Length of spike (cm)	1	At harvest
2	Number of spikes $plant^{-1}$	1	At harvest
3	Weight of spike (g)	1	At harvest
4	Number of grains $spike^{-1}$	1	At harvest
5	Grain yield plant-^{1} (g)	1	At harvest

6	Straw yield plant^{-1} (g)	1	At harvest
7	Test weight (g)	1	At harvest
8	Biological yield ha^{-1} (q)	1	At harvest
9	Harvest index (%)	1	At harvest
10	Grain to straw ratio (%)	1	At harvest

2.6.1. Length of spike (cm)

From the base of the lowest spikiest spike to the topmost spikelet, the length of the spike was measured using a centimeter measuring scale. Five randomly selected plants from the middle rows of each unit plot were measured for spike length, and the average mean of the five plants' spike lengths was taken into account.

2.6.2. Number of spikes plant^{-1}

Five plants from each unit plot in the middle of the rows were chosen at random for this character's purposes. The number of spikes on each plant was manually counted from each harvested plant separately, and the average mean was taken into consideration.

2.6.3. Weight of spike (g)

To do this, five plants were randomly selected from the middle rows of each unit plot. Each plant's weight was recorded in grams on a weighing balance, and the average mean was taken into account.

2.6.4. Number of grains spike^{-1}

Following maturity, five plants from the middle rows of each unit plot were randomly picked. The average mean number of grains was taken into consideration, and the number of seeds from each of the five plants was manually counted.

2.5.5. Grain yield plant^{-1} (g)

Using a measuring balance, the grains from five plants in each unit plot were gathered separately for each plant, and the average weight of each plant was calculated in grams. Following the correct drying, cleaning, and weighting of each unit plot's grains (economic produce), the yield was determined in quintals per hectare.

2.6.6. Straw yield plant^{-1}(g)

Five plants were chosen at random from each unit plot for this character, and the average straw production for each plant was calculated by cleverly subtracting the grain weight with the use of a weighing balance. By subtracting the grain weight from the weight of all the harvested output from each plot, the straw yield in kilos was converted to quintals per hectare.

2.6.7. Test weight (g)

Each net plot's 1000 seeds were manually counted, and the weight of the 1000 grains was measured using a weighing scale and taken into account in grams for the purposes at hand.

2.6.8. Biological yield (q ha^{-1})

The dry weight of straw yield in quintals per hectare and the yield of seeds in quintals per hectare were added separately to get the biological yield per hectare, which was then calculated in quintals.

2.6.9. Harvest Index (%)

A crop's ability to generate seed yield per unit of overall biological yield was evaluated by the Harvest Index. Donald (1962) provided the following formula, which was used to calculate the Harvest Index for various treatments.

$$\text{Harvest index (\%)} = \frac{\text{Economical yield}}{\text{Biological yield}} \times 100$$

2.6.10. Grain to straw ratio

Each unit plot's grain yield to straw yield ratio was computed and displayed in ratios.

2.7. Statistical analysis and interpretation of Data

Utilizing the SPSS software and fundamental statistical methods for analysis of variance, the experimental data collected during the investigation were examined using a Factorial Randomized Block Design (Gomez and Gomez, 1984). The comparison of treatment means was conducted with a crucial difference calculated at the P = 0.05 levels and the results were significant regardless. Data on interaction effects are shown when they are considered significant. The treatment's effects are suitably shown in tables and shown in graphs and charts.

RESULTS AND DISCUSSION

The results are discussed with a comprehensive understanding of the relationship between many factors, including as spacing and sowing methods, and crop output. The sowing method S5 (dibbling at 20 x 20 cm) was found to have significantly higher yield attributes, including number of spike plants^{-1}, length of spike (cm), number of grain spike^{-1}, weight of spike (g), grain yield plant^{-1} (g), straw yield plant^{-1} (g), test weight (g), number of grains plant^{-1}, grain yield plant^{-1} (g), straw yield plant^{-1} (g), biological yield (q h^{-1}) and test weight (g). The treatments S3 (dibbling at 15 x 15 cm) and S1 (drilling at 20 cm @100 kg seed ha^{-1}) resulted in considerably greater grain yield (q ha^{-1}), straw yield (q ha^{-1}), biological yield (q ha^{-1}), harvest index (%), and grain to straw ratio.

3.1. Number of spikes plant^{-1}

Table 3 illustrates the strong impact of types on number spike plant^{-1}. Compared to variation V2 (AKAW 4627), variant V1 (AKAW 4210-6) generated a noticeably greater number of spike plants per plant. The genetic components that produce the number of functional tiller plants per plant may be the cause of this. Numerous factors, such as the length of the vegetative phase, which may lengthen due to wider spacing within the plants depending on the sowing methods, may cause wheat plants to produce more spikes. Effect of sowing treatments was significantly influenced the number of spikes plant^{-1}.Treatment Following S4 (dibbling at 15 x 20 cm), S3 (dibbling at 15 x 15 cm), S2 (drilling @ 50 kg ha^{-1}), and S1 (drilling @ 100 kg ha^{-1}), S5 (dibbling at 20 x 20 cm) recorded the considerably greatest number of spike plants^{-1} (7.29 spikes plant^{-1}). More spike plants per plant may result from increasing spacing at the ideal level, which eventually contributes to increased grain output by increasing the quantity of grains per plant. There was no significant interaction impact. Contrary to this, Hussain et al. (2012) claimed that a low grain yield could be caused by a loss in productive tillers, even with a considerable increase in the number and size of grains in wider rows. Raghuvanshi et al. (2020) and Abhishek et al. (2021) also noted these comparable results.

3.2. Length of spike (cm)

The findings presented in Table 2 indicate that the impact of variety on spike length was substantial for variation V1 (AKAW 4210-6), which exhibited the longest spike length compared to variety V2 (AKAW 4627). Variations in spike length may result from the genetic composition of different cultivars as well as increased plant spacing, which promotes greater light interception and lengthens the vegetative phase. The highest spike length at treatment S 5 (20 x 20 cm) was followed by S4 (15 x 20 cm) and S3 (15 x 15 cm) dibbling. The interaction effect between sowing techniques and varieties was not significant enough. Anbessie et al. (2020), also discovered these outcomes.

3.3. Number of grains spike^{-1}

The findings presented in Table 2 indicate that the impact of variety on spike length was substantial for variation V1 (AKAW 4210-6), which exhibited the longest spike length compared to variety V2 (AKAW 4627). Variations in spike length may result from the genetic composition of different cultivars as well as increased plant spacing, which promotes greater light interception and lengthens the vegetative phase. The highest spike length at treatment S 5 (20 x 20 cm) was followed by S4 (15 x 20 cm) and S3 (15 x 15 cm) dibbling. The interaction effect between sowing techniques and varieties was not significant enough. Anbessie et al. also discovered these outcomes (2020).

3.4 Weight of spike (g)

Table 2's results show that the weight of the spike, which was attained well, was greatly impacted by the cultivars and planting techniques. The spike plant^{-1} weight of variety V1 (AKAW 4210-6) was much higher (2.81 g plant^{-1}) than that of variety V¬2 (AKAW 4627), which was 2.66 g plant^{-1}. The genetic components of cultivars may be the cause of this. The increased spacing between plants may potentially contribute to the variation in spike weight by increasing light interception and lengthening the vegetative period. Additionally, it was noted that, out of all the sowing techniques, treatment S5 (dibbling at 20 x 20 cm) produced the noticeably greatest weight of spike plant^{-1} (3.18 g). Treatment S5 was shown to be comparable to treatments S3 and S4, which involved dabbling at 15 × 15 cm and 15 x 20 cm, respectively. These findings concurred with those of Anbessie et al. (2020).

3.5 Grain yield plant^{-1}

Table 3's results demonstrate that sowing techniques and variety had a substantial impact on grain yield plant^{-1}. 11.05 g was the average grain yield per plant. The treatment of the cultivars had a considerable impact on the grain production per plant. Grain production per plant was considerably higher in variation V1 (AKAW 4210-6) than in variety V2 (AKAW 4627). The quantity of grain plants^{-1} was greatly impacted by the sowing treatments. Compared to all other sowing techniques, treatment S5 (dibbling at 20 × 20 cm) produced the noticeably largest grain production per plant. However, it was discovered that treatment S5 was comparable to treatments S3 and S4 (dibbling at 15 x 15 cm and 15 x 20 cm, respectively).

The interaction impact between varieties and the manner of seeding was not significant enough. Johnson et al. (1988) , Marshall and Ohm (1987) also discovered similar outcomes. According to Thorsted et al. (2006), enhanced inter-specific interactions and decreased intra-specific competition during the growing season may be the cause of the improved wheat grain production in wider rows.

3.6 Straw yield plant^{-1} (g)

Table 3's results demonstrate that sowing techniques and variety had a substantial impact on straw yield plant^{-1}. It was found that the average straw output per plant was 24.15 (g). The treatment of the types had a substantial impact on the straw yield plant^{-1}. Straw yield per plant was considerably higher in variety V1 (AKAW 4210-6) than in variation V2 (AKAW 4627). It was discovered that different seeding techniques had a considerable impact on the amount of straw produced per plant. Compared to all other sowing techniques, treatment S5 (dibbling at 20 x 20 cm) had the maximum straw production per plant. It could be because there are more tillers per plant in larger rows as opposed to narrower ones. The interaction impact between varieties and the manner of seeding was not significant enough. Ali et al. (2010) and Malik et al. (1996) came to similar conclusions.

3.7 Test weight (g)

Varieties' effects on test weight had a major impact on the 1000 grain weight diversity Variety V1 (AKAW 4210-6) has a higher test weight than variety V2 (AKAW 4627); this difference in test weight may be caused by the variety's genetic composition (table 3). The test weight was greatly impacted by the sowing techniques. S5 treatments (dibbling at 20 x 20 cm) outperform all other methods of sowing. S1 (drilling at 100 kg ha^{-1}) and S2 (drilling at 50 kg ha^{-1}) were shown to be inferior to S3 (15 x 15 cm). Wider rows were shown to have higher 1000 grain weights, which may be the result of more effective use of light, water, and nutrients because there is less competition between rows and fewer plants. Hussain et al. (2012), Ali et al. (2010), and Iqbal et al. (2010) all provided similar findings. Chen et al. (2008) and Abhishek et al. (2021) also noted these comparable results.

Table 3 Number of spike plant^{-1}, length of spike (cm), number of grains spike^{-1}, weight of spike (g), grain yield plant^{-1} (g), straw yield plant^{-1}(g) and test weight (g) as influenced by various treatments of wheat varieties.

Treatments	Number of spike plant^{-1}	Length of spike (cm)	Number of grains spike^{-1}	Weight of spike (g)	Grain yield plant^{1} (g)	Straw yield plant^{-1} (g)	Test weight (g)
Varieties							
V_1- AKAW-4210-6	5.76	9.7	59.33	2.81	11.59	24.79	41.17
V_2- AKAW 4627	4.75	9.4	55.06	2.66	10.51	23.50	39.93
S.E. (m) ±	0.18	0.08	0.41	0.014	0.28	0.27	0.39
C.D. at 5%	0.55	0.26	1.22	0.042	0.83	0.81	1.17
Sowing Method							
S_1-Drilling @ 100 kg ha^{-1}	2.05	9.2	40.5	1.92	8.03	20.55	39.6
S_2-Drilling @50 kg ha^{-1}	3.04	9.4	49.0	2.06	8.46	21.41	40.17
S_3-Dibbling at 15 x 15 cm spacing	6.75	9.6	62.5	3.10	12.47	25.33	40.47
S_4-Dibbling at 15 x 20 cm spacing	7.17	9.7	66.5	3.18	12.83	25.54	41.33
S_5-Dibbling at 20 x 20 cm spacing	7.29	9.8	67.5	3.42	13.46	27.92	42.18
S.E. (m) ±	0.29	0.07	0.64	0.022	0.44	0.43	0.62
C.D. at 5%	0.87	0.21	1.92	0.06	1.32	1.29	1.85
Interaction (V x S)							

S.E. (m) ±	0.41	0.10	0.91	0.03	0.63	0.61	0.88
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS
GM	5.26	9.56	57.2	2.74	11.05	24.15	40.69

3.8 Yield studies

Results for harvest index (%), grain to straw ratio, biological yield (q ha-1), grain yield (q ha-1), and straw yield (q ha_{-1}) were displayed in Table 4 and visually depicted in Figures 1 and 2.

3.8.1 Grain yield (q ha^{-1})

Wheat cultivars and sowing techniques had a major impact on grain yield. Variety V1 (AKAW 4210-6) reported the highest grain yield (38.48 q ha^{-1}), followed by variety V2 AKAW 4627 (35.74 q ha^{-1}); these differences in grain yield are substantial (Table 3 and figure 1). The variations in grain production between the sowing procedures were considerable; the maximum grain yield (41.10 q ha^{-1}) was obtained by treatment S3 (dibbling at 15 x 15 cm), followed by S1 (drilling @100 kg ha-1) with 37.91 (q ha^{-1}), and S4 (dibbling at 15 x 20 cm) with 36.31 (q ha_{-1}) (Table 3 and figure 2). Likewise, it was discovered that treatment S2 (drilling at 50 kg ha^{-1}) was significantly superior to treatment S5 (dibbling at 20 x 20 cm). These findings are consistent with those of Hasan et al. (2010) and. Abhishek et al. (2021).

3.8.2 Straw yield (q ha^{-1})

Variety V1 AKAW 4210-6 recorded the highest straw yield (84.95 q ha^{-1}), followed by variety V2 AKAW 4627 (81.52 q ha^{-1}) (Table 3 and picture 1). Varieties of straw yield differ significantly.. Significant variations in straw production are caused by the sowing technique; treatment S3 (dibbling method at 15 cm x 15 cm) produced the highest straw yield (92.54 (q ha^{-1})) compared to treatment S1 (drilling at 20 cm @ 100 kg ha^{-1}) with 84.91 (q ha^{-1})). For straw yield, interaction effects are not significant (Table 3 and image 2). Malik et al. (1996), Ali et al. (2010), Satyanarayana et al. (2017), and Gundaboina and Mehera (2022) all came to similar conclusions.

3.8.3 Biological yield (q h^{-1})

The biological yield was greatly impacted by the examined types. According to Table 3 and Figure 1, variety V1 (AKAW 4210-6) had the highest biological yield (123.43 q ha^{-1}), followed by variety AKAW 4627 (117.18 q ha^{-1}). The overall mass of the plant, including the grains and straw, might vary based on the genotypes, seed kinds, and sowing techniques, among other factors. The biological yield was greatly impacted by the effects of the sowing techniques. Compared to the other sowing techniques, S3 (dibbling method at 15 cm x 15 cm) had the highest biological output (134.64 q ha^{-1}), followed by drilling at 20 cm @ 100 kg ha^{-1} (122.82 q ha-1). For straw yield, interaction effects are not significant (Table 3).These results concur with Kobata et al. (2018) and Singh et al. (2024).

3.8.4 Harvest Index (%)

It is the proportion of the total dry matter of plant shoots to the grain yield. It is a gauge of how effectively a plant devotes its resources to procreation. Compared to those acquired with population density, it may have been obtained due to a larger population density. The highest harvest index (31.13%) was reported by variety V1 AKAW 4210-6, which was followed by variety AKAW 4627-30. The highest harvest index (31.25%) was obtained using the dibbling method at 15 cm × 15 cm (Table 3 and image 2). Plant spacing and varietal differences may be the cause of this. For the harvest index, interaction effects are not significant. The outcomes support the conclusions of Singh et al. (2003) and Gundaboina and Mehera (2022).

3.8.5 Grain to straw ratio

It is the proportion of grain to straw, and it varies by variety, location, and time of year. Grain to straw ratios were highest for variety V1 AKAW 4210-6 (0.45), followed by variety AKAW 4627 (0.43). The sowing technique had a major impact on the grain to straw ratio. In S3 (dibbling at 15 x 15 cm) and S4 (dibbling at 15 x 20 cm), the grain to straw ratio was 0.45, while in S1 (drilling at 20 cm @100 kg ha^{-1}), it was 0.44 (table 3 and figure 2). For the ratio of grain to straw, interaction effects are not significant. These results were consistent with those of Gundaboina and Mehera (2022).

Table 4: Grain yield (q ha^{-1}), straw yield (q ha^{-1}), biological yield (q ha^{-1}), harvest index (%), grain to straw ratio as influenced by various treatments of wheat varieties

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest Index (%)	Grain to Straw ratio
Varieties					
V_1- AKAW-4210-6	38.48	84.95	123.43	31.13	0.45
V_2- AKAW 4627	35.74	81.52	117.18	30.45	0.43
S.E. (m) ±	0.68	0.69	1.28	-	-
C.D. at 5%	2.04	1.94	3.01	-	-
Sowing Method					
S_1-Drilling @ 100kg ha^{-1}	37.91	84.91	122.82	30.85	0.44
S_2-Drilling @50 kg ha^{-1}	36.08	79.75	115.83	31.13	0.44
S_3-Dibbling at 15 x 15 cm spacing	41.10	92.54	134.64	31.25	0.45
S_4-Dibbling at 15 x 20 cm spacing	36.31	79.99	116.15	31.21	0.45
S_5-Dibbling at 20 x 20 cm spacing	33.16	78.99	112.09	29.52	0.42
S.E. (m) ±	1.09	1.03	2.01	-	-
C.D. at 5%	3.24	3.07	5.14	-	-
Interaction (V x S)					
S.E. (m) ±	1.53	1.46	2.97	-	-

C.D. at 5%	NS	NS	NS	-	-
GM	37.11	83.23	120.30	30.79	0.44

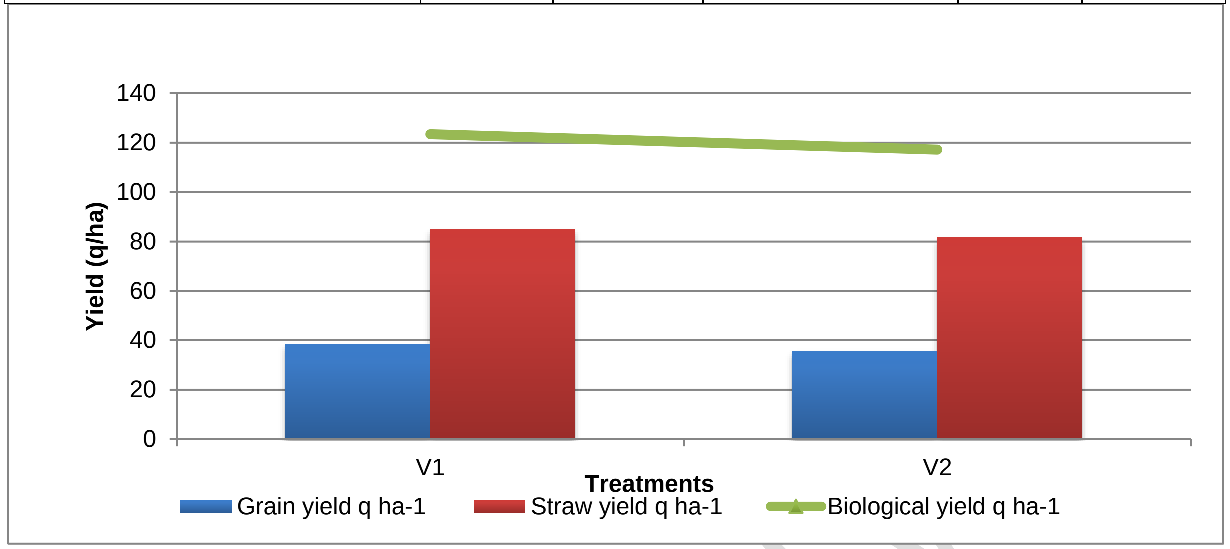

Fig. 1. Grain, straw and total biological yield (q ha^{-1}) as influenced by varieties

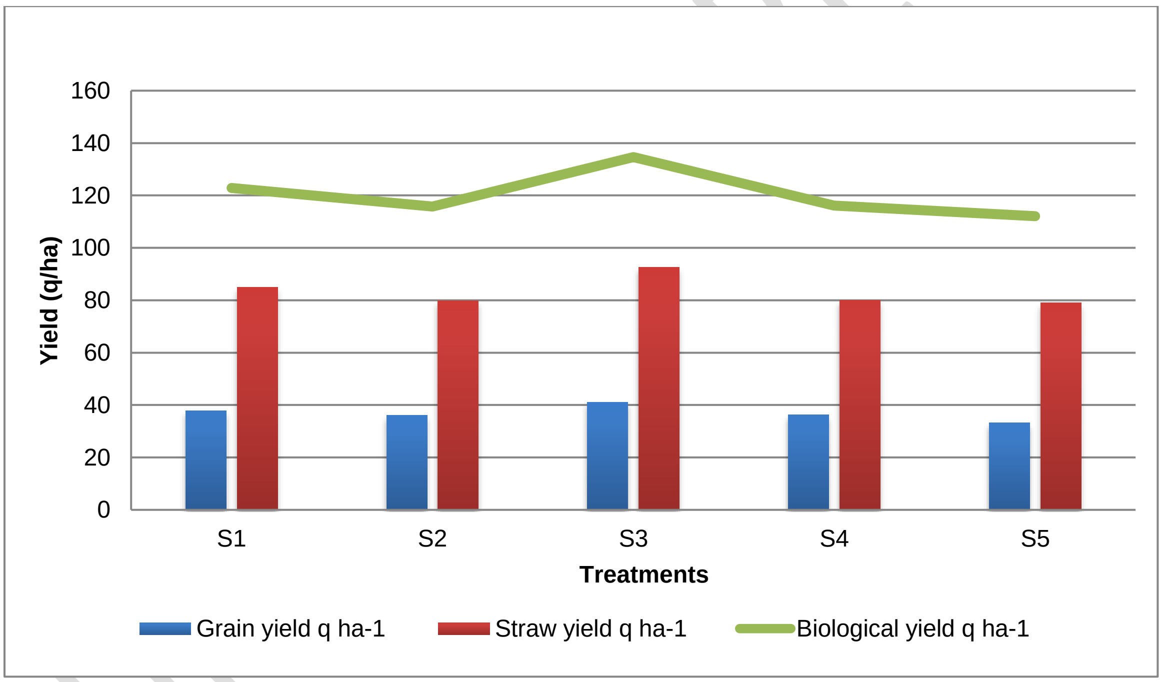

Fig. 2. Grain, straw and total biological yield (q ha^{-1}) as influenced by sowing methods

CONCLUSION

It was discovered that treatment diversity brought on by various seeding methods was significant at every stage of crop growth. When compared to AKAW 4627, variety AKAW 4210-6 had the highest grain output. The dibbling approach at 15 cm x 15 cm recorded the highest grain yield compared to the drilling method at 20 cm @ 100 kg ha^{-1}, and the changes in grain production caused by the sowing method are substantial. The sowing methods S5 (dibbling at 20 x 20 cm), S3 (dibbling at 15 x 15 cm), S4 (dibbling at 15 x 20 cm), and the remaining treatments were shown to have considerably greater yield qualities. Treatment S3 (dibbling at 15 x 15 cm) was considerably higher than treatment S1 (drilling at 20 cm @100) in terms of grain yield (q ha^{-1}), straw yield (q ha^{-1}), biological yield (q ha^{-1}), harvest index (%), and grain to straw ratio.

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