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Effect Of Different Seed Rates On New Wheat Genotypes Under Thal Irrigated Conditions

Rana Javaid Iqbal*[1] , Khalid Mehmood Mughal[2] , Nadeem Hussain[3] , Asim Pervez[4] , Munir David[5] , Muhammad Iqbal Shahid[6] , Syed Sajjad Haider Kazmi[7]

[1]Soil Fertility Research Institute, Lahore-54000, Punjab, Pakistan

[2]Statistical Section, Ayub Agriculture Research Institute Faisalabad-38000, Punjab, Pakistan

[3]Soil Fertility Section Sargodha-40100, Punjab, Pakistan

[4]Citrus Research Institute, Sargodha-40100, Punjab, Pakistan

[5]Provincial Reference Fertilizer Testing Laboratory, Raiwind, Lahore-54000, Punjab Pakistan.

[6]Regional Agricultural Research Institute Bahawalpur-63100, Punjab Pakistan.

[7]Soil and Water Testing Laboratory Research Lahore-54000, Punjab Pakistan

Abstract

A field experiment was carried out in Agronomic Research Station Karor at Layyah. Four seed rates (75kg ha^{-1},100kg ha^{-1},125kg ha^{-1} and 150kg ha^{-1}) and five varieties (Akhbar-19, Bakhar Star-19, Fakhar e bhaker, TWS-15137 and TWS-15159) were selected. The experiment was based on RCBD (Randomized Complete Block Design) with two factorial arrangements and three times replication. The size of plot was 6m*1.35m (8.1m^2) and the row-to-row distance of the wheat plant kept 22.5cm. The result of different seed rate treatments was significant on yield parameters of wheat. Seed rates significantly affected grain yield of wheat ha^{-1}. Wheat productivity could be improved with optimized seed rate for different varieties. This year study was conducted to determine the optimum seed rate for different varieties of wheat for better yield and related components. Increase in seed rate improved the number of productive tillers per m^2 and grain yield of all wheat varieties although productive tillers per plant, number of grains per spike and 1000-grain weight was increased. Fakhar e Bhakkar and Bhakkar Star performed better regarding grain yield and related components among all varieties. Plant height and spike length did not affect significantly on grain and different seed rate of varieties. Correlation analysis revealed that grain yield was positively correlated with number of productive tillers per m^2 during years and grain weight during year.

Introduction

The recent pandemic COVID-19 poses extraordinary challenges for almost all sectors of the economy of Pakistan (Susskind and Vines. 2020) The need for maintaining food security and livelihoods has also gained more importance. The cereal markets are expected to remain balanced and comfortable despite uncertainties over the impact of COVID-19. As logistical issues may pose challenges to food supply it is

important to take measures for boosting agriculture production which will contribute in mitigating the socio-economic impact of COVID-19 (Jámbor et al. 2020)

Wheat resembles for 8.7% and 1.7% GDP value added in agriculture. In 2020, wheat crop production was 24.946 million tons while over last year wheat production 24.349 million tons which increased by 2.5 percent (Sánchez et al. 2022). The cultivation area wheat crop production increased by 1.7% to 8,825 thousand hectares while wheat crop was 8,678 thousand tons hectares in 2019 (Ayub et al.2022). Due to better crop yield, healthy grain formation and increasing of cultivation area crop production of wheat increased (Pakistan economic survey 2020).

The Prosperity of Pakistan depends directly and indirectly on proper wheat husbandry and therefore, any improvement in yield and production will improve the food situation of the country and well-being of the farmers and all others (Yadav et al.2019). The future targets, to meet the food requirements of the growing populations, can be achieved either increasing area under wheat or maximizing yield, or by adoptive appropriate production technology with use of high yielding varieties, proper sowing time, optimum seed rate, adequate amount of fertilizers and proper planting geometry (Ullah et al. 2019). Among the several factors responsible for low yield in Pakistan, low planting use of unbalanced rate of fertilizers and inappropriate seed rats are important and research on these limiting factors will surely lead to high yields (Azmeraw. 2022). Optimum seed rate is most important for maximum yield of crop. If more seed rate is used, plant population will be more and there will be competition among plants for water, nutrients and sunlight.

Environmental variation could cause the problem in phenology, growth and yield. The key challenge are ideal sowing time and optimum rate of seed to sustain the wheat productivity under changing environment (Hussain et al., 2012a; Asseng et al., 2015).

Farmers are trying to produce more grain per unit area of land. Plants breeder are taking experiment to produce better varieties of crop yield and crop rotations and agronomic practices which will help the farmers to get more grain. (Shah et al. 2021). These workers like farmers who work in field have made good improvement of wheat production, and in previous years wheat growers have had the chance to select a variety from different types (Hochman and Horan. 2018) Some of the varieties differ considerably in plant characteristics and yielding ability. Theses difference in plant characteristics and yield ability often raises questions relative to certain cultural practices.

Experiment on seed rate of wheat have introduced the importance of seeding rate on yield have generally ignored the influence of seeding rate on the yield components (Melash, et al. 2019). Conversely, determinations of the yield components have not been based on planned variations in plant density. Any increase in yields that may be gained by varying the rate of seeding is a relatively inexpensive advantage to the grower.

For area and production in the World, wheat (Triticum aestivum L.) is a crop of cereal food. In 2010, more than 216 million hectare area of land were being grown with a total production of 651 million tons of grain (FAOSTAT, 2012).Planting time has close association with weather parameter, increase in temperatures affected the crop yield because of shorten the length of growing season (Olesen et al., 2011;

Ahmed et al., 2018).The growth and yield of wheat plants are suffered due to uncertain rainfall season. Between several crop management factors which are sowing method, seeding rate and suitable genotype have play a character in affecting wheat productivity (Chauhdary et al., 2016; Isidro-Sánchez et al., 2017). Ridge sowing of wheat enhances the crop yield and saving of water by improving tillering capacity of plant, soil moisture content and nutrient availability (Hussain et al., 2018). Hence, optimization of seed rate with suitable selection of variety is necessary for maintaining proper distant of plant population to get better crop yield from ridge sown wheat (Chauhdary et al., 2016).

Optimum seed rate is an important factor which regulates the ability of crop plants to meet the available resources (Lloveras et al., 2004). Wheat is a source of nutrition in food which is rich in proteins, minerals, vitamins and dieting fiber (Afzal et al., 2013; Kumar et al., 2011). . The proper sowing date for wheat in Punjab ranges from 1st to 25th November and specifically for Faisalabad it ranges from 10th November to 25th November, and proper seed rate for wheat in Faisalabad is 125 kg ha-1 (Said et al., 2012). Each week delay of wheat sowing reduces the crop vegetative length and reproductive stages and causes yield reduction (Akmal et al., 2011). Malik et al. (2009) reported that high seed rate of wheat causes the reduction in germination count and tillers. Intra and interplant competition for light, water and nutrients were influenced by the seed rates. The objectives of these experiments were to find out:

- How the different rates of seeding influenced yield.
- The yield components of winter wheat seasons.
- To determine the optimum seeding rates for both varieties and to see if low seeding rates of these varieties could give satisfactory yields.

Materials and Methods

An experiment to determine the effect of seed rate on growth, yield and quality of wheat was conducted at Agronomic Research Station Karor, Layyah which is located at $31^0 13'$ on $70^0 57'$OE with an altitude of 148 meters (488 feet). The city is located on the west coast of the Indus River. The city is located to East of Indus River Suleiman Mountain ranges; hence the lands in vicinity of river are much fertile growing usually wheat and mixed cropping system.

2.1 Experimental design and Layout:-

The experiment was laid out in Randomized Complete Block Design (RCBD) with split plot arrangement, with three replications. Net plot size was 6m *1.35m ($8.1m^2$).

2.1.1 Treatments

A. Variety:-

$\mathbf{V}_1$=Akhbar-19

$\mathbf{V}_2$=Bhakkar Star-19

$\mathbf{V}_3$=Fakhar e Bhakkar

$\mathbf{V}_4$=TWS-15137

V_5=TWS-15159

B. Seed Rate:-

S1=75 kg ha^{-1}

S_2=100 kg ha^{-1}

S_3=125 kg ha^{-1}

S_4=150 kg ha^{-1}

2.1.2 Layout Plan for Experiment;

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R_3	S_2	S_1	S_4	S_3	S_2	S_1	S_4	S_3	S_2	S_1	S_4	S_3	S_2	S_1	S_4	S_3	S_2	S_1	S_4	S_3
R_2	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4
R_1	S_4	S_3	S_2	S_1	S_4	S_3	S_2	S_1	S_4	S_3	S_2	S_1	S_4	S_3	S_2	S_1	S_4	S_3	S_2	S_1
	V_5: 15159				V_4: 15137				V_3: Fakhar e bhaker				V_2: Bhakkar Star – 19				V_1: Akbar – 19			

Farm road

S_1: 75 kg ha^{-1} Design: RCBD factorial with three replication
S_2: 100 kg ha^{-1} Plot size: 6m × 1.35m = (8.1m^{-2})
S_3: 125 kg ha^{-1} R × R 22.5 cm
S_4: 150 kg ha^{-1} No of Rows/plot: 06 (spare 01 rows after each seed rate)
S_1: 61 g/plot NPK kg/ha:130; 115; 62
S_2: 81 g/plot Path width:
S_3: 101 g/plot
S_4: 121.5 g/plot

2.2 Parameters Recorded;-

There were following parameters recorded during the course of study;

- Plant height(cm)
- Spike length(cm)

- No of spikelet per spike
- No of tillers per m^2
- 1000 grain weight
- Grain Yield
- Biological yield
- Harvesting Index %

2.2.1 Plant height:-

Plant height was measured in cm with a large measuring scale from the soil surface to the point of attachment of stem to top of five randomly selected plants from each experimental plot. Then the average height was computed.

2.2.2 Spike length:-

It was recorded with measuring small scale in cm and five plants selected randomly from each experimental plot. Then the average height was computed.

2.2.3 No of Spikelet per spike;-

A random sample of ten spikes was selected from each plot. The number of spikelet which was developed fully counted for each spike and the average determined.

2.2.4 No Of Tillers per m^2;-

It was recorded by randomly throwing of one square meter rod on each plot. After throwing of rod ($1m^2$) on wheat plot area, counted the number of tillers in rod.

2.2.5 1000 grain weight:-

The sample each of 1000-grain were taken from the seed bag of each plot, weighed on electronic balance and their average was calculated.

2.2.6 Grain Yield;-

Matured plants were harvested, the heads were detached from stem, dried under sunlight and threshed manually. The grain yield per plot was recorded.

2.2.7 Biological Yield:-

Weight of sun dried plants was recorded on plot basis and then converted into kg ha^{-1}.

2.2.8 Harvesting Index:-

Harvest index show the proportion of grain yields to biological yields. Harvest index was calculated by the following formula;

Harvest index= grain yield/biological yield*100

2.2.9 Statistical analysis:-

Data were statistically analyzed using analysis of variance (ANOVA) techniques appropriate for the split-plot, randomized complete block deign using computer based software SAS. Significant differences among treatments were determined with least significant difference test.

Result and discussion

Plant height

Table1.

Varieties	Sowing rate				Mean
	S_1 75 kg ha^{-1}	S_2 100 kg ha^{-1}	S_3 125 kg ha^{-1}	S_4 150 kg ha^{-1}	
Akbar – 2019	92 g	94 e-g	93 e-g	95 d-g	94 c
Bhakkar Star	98 b-g	98 b-g	100 a-e	100 a-f	99 b
Fakhar Bhakkar	101 a-d	105 a	100 a-d	103 a-c	102 a
TWS – 15137	93 fg	102 a-d	103 ab	97 c-g	99 b
TWS – 15159	98 b-g	97 c-g	95 d-g	93 e-g	96 bc
Mean	97	99	99	98	
LSD $_{5\%:}$ Sowing rate = ns, varieties = 3.40, Interaction = 6.27					

Table 1 shows that seed rate did not affect significally upon the plant height but varieties changed the plant height. The maximum plant height was reorded in Fakhar e Bhakkar and least plant height was observd in Akhbar-19. Similar results were obtained during experimentation by Naveed et al. (2014) and Musaddique et al. (2000) for various varieties during which they observed that each variety has its own feature from the growth viewpoint and variation in plant height was recorded as their genetic variety. Our results are in accordance with the findings of Shuaib (2010) who reported that Plant height is considered as a genetic character of variety of a plant which is modified by the environmental conditions under which it is grown.

Spike length

Table2.

Varieties	Sowing rate				Mean
	S_1 75 kg ha^{-1}	S_2 100 kg ha^{-1}	S_3 125 kg ha^{-1}	S_4 150 kg ha^{-1}	
Akbar – 2019	11 a-d	10 cd	10 b-d	10 a-d	10 b
Bhakkar Star	10 a-d	10 a-d	10 b-d	11 a-c	10 ab
Fakhar Bhakkar	11 a	11 ab	11 a	10 a-c	11 a
TWS – 15137	10 a-d	10 a-d	10 b-d	10 cd	10 b
TWS – 15159	10 a-d	10 d	10 cd	10 cd	10 b
Mean	11	10	10.	10	
LSD 5%: Sowing rate =NS, Varieties = 0.559, Interaction =0.5824					

Table 2 gives result that maximum spike length was obtained in Fakhar e Bhakkar (11cm) while spike length was also in Bhakkar Star-2019(11cm). It was observed that seed rate did not significantly effect on spike length. This variation in spike length is due to genetic variability among different genotypes thus producing spikes of different length.

Our results are in line with the results of Naveed et al. (2014) and Mushtaq et al. (2011) those found many variations in spike length along with other growth parameters in wheat crop. Nadeem (2001) and Shuaib (2010) were of the view that spike length variation among different cultivars is due to variation of available soil nutrients and prevailing environments at particular site in combination with genetic inheritance of that cultivar. Thus, favorable growing period and nutrients availability are dominantly expressed in terms of long spike length by test.

No of tillers per m^2:

Table 3.

Varieties	Sowing rate				Mean
	S_1 75 kg ha^{-1}	S_2 100 kg ha^{-1}	S_3 125 kg ha^{-1}	S_4 150 kg ha^{-1}	
Akbar – 2019	287 e-h	322 b-e	352 ab	366 a	332 ab
Bhakkar Star	321 b-e	315 b-e	348 a-d	272 g-i	314 bc
Fakhar Bhakkar	323 b-e	380 a	374 a	346 a-d	356 a
TWS – 15137	252 h-i	309 d-g	306 e-g	312 c-f	295 c
TWS – 15159	309 d-g	273 f-i	349 a-c	244 i	293 c
Mean	298 c	320 b	346 a	308 bc	
LSD 5%: Sowing rate =15.466, Varieties =25.401, Interaction =34.586					

Table3 shows that maximum tillers were found in Fakhar e Bhakkar variety of wheat at a seed rate of 100kg ha^{-1} while tillers were also obtained maximum in Akhbar-19 variety at a seed rate of 150kg ha^{-1} and least minimum tiller were obtained in TWS-15159 at a seed rate of 150kg ha^{-1}. These results are in conformity with the finding of Jan et al. (2000), Malik et al. (2009) and Sarker et al. (2009) who obtained the highest number of tillers per m^2 by using the highest seed rate. Tunis et al. (1995) found increase in spike number at higher wheat densities established better crop and good competition with weeds. Consequently, more tillers m^{-2} was obtained. It was observed that number of tillers increased with increase in seed rate in akhbar-19. The increase in number of tillers per m2 due to higher seed rate was mainly associated with higher number of plants per m2 (emergence count) as it was also evident from the fact that the average number of tillers per plant was decreased, as compared to low seed rate.

Biological yield:

Table 4.

Varieties	Sowing rate				Mean
	S_1 75 kg ha^{-1}	S_2 100 kg ha^{-1}	S_3 125 kg ha^{-1}	S_4 150 kg ha^{-1}	
Akbar – 2019	2016 cd	2469 a	2098 b-d	1851 d	2109 b
Bhakkar Star	1975 cd	2098 b-d	2098 b-d	2222 a-c	2098 b
Fakhar Bhakkar	2222 a-c	2345 ab	2222 a-c	2345 ab	2283 a
TWS – 15137	1975 cd	2098 b-d	1975 cd	1975 cd	2006 b
TWS – 15159	1975 cd	2098 b-d	1975 cd	1975 cd	2006 b
Mean	20329 b	2222 a	2074 b	2074 b	
LSD 5%: Sowing rate =1339, Varieties =1598 , Interaction =2994					

Biological yield is an important parameter to determine the photosynthetic efficiency of a crop. Data about biological yield is presented in table (4). Results regarding the biological yield (kg ha^{-1}) show significant differences for biological yield per hectare of wheat among various zinc sowing rate and varieties. The interactions between varieties and sowing rates were also significant. Table (4) shows that biological yield were maximum in Fakhar e 624hakkar variety at a seed rate of 100 kg ha^{-1} and 150 kg ha^{-1}. While minimum yield produced in Akhbar-2019 at a seed rate of 150 kg ha^{-1}. Moreover, it has been observed that increase in plant population due to increase in seed rate results in decrease in number of grains per spike and grain weight due to competition among plants for available resources (Faris and Pauw, 1980; Iqbal et al., 2010; Isidro-Sánchez et al., 2017).

Grain yield.

Table 5.

Varieties	Sowing rate				Mean
	S_1 75 kg ha^{-1}	S_2 100 kg ha^{-1}	S_3 125 kg ha^{-1}	S_4 150 kg ha^{-1}	
Akbar – 2019	5113 hi	5370 gh	5778 c-g	5603 f-h	5460 c
Bhakkar Star	6085 b-f	6079 b-f	6323 bc	6392 b	6220 a
Fakhar Bhakkar	5735 e-g	5778 c-g	6565 b	6247 b-e	6081 ab
TWS – 15137	5417 gh	6341 bc	6566 b	5803 c-g	6032 ab
TWS – 15159	4723.3 i	5448 gh	6317 b-d	7151 a	5910 b
Mean	5415 c	5803 b	6305 a	6239 a	
LSD 5%: Sowing rate =262 , Varieties =248 , Interaction =586					

It has been observed that grain yield increases with increase in seed rate as under table 5.As we see that TWS-15159 variety produced maximum grain yield at a seed rate of 150kg ha^{-1}.It means that grain yield can be increased with increase in seed rate. The increase in grain yield due to increase in seed rate was associated with enhanced number of productive tillers per m2 although average number of tillers per plant, number of grains per spike and grain weight was decreased, as compared to low seed rate. Similarly, Chauhdary et al. (2016) reported that higher seed rate (160 kg ha^{-1}) increased the number of tillers per m2 and grain yield of bed planted wheat while decreased number of grains and grain weight, as compared to low seed rates (100 and 130 kg ha^{-1}).

Harvest index:

Table6.

Varieties	Sowing rate				Mean
	S_1 75 kg ha^{-1}	S_2 100 kg ha^{-1}	S_3 125 kg ha^{-1}	S_4 150 kg ha^{-1}	
Akbar – 2019	29 b-d	26 de	24 e	39 a	30 a
Bhakkar Star	28 b-e	31 b	30 bc	31 b	30 a
Fakhar Bhakkar	28 b-d	26 c-e	26 de	27 b-e	27b
TWS – 15137	27 c-e	28 b-e	26 de	29 b-d	27b
TWS – 15159	26 de	28 b-e	26 de	28 b-e	27 b
Mean	27 b	28 b	26 b	31 a	
LSD 5%: Sowing rate = 1.72, Varieties =1.71, Interaction =3.86					

Harvest index shows the photosynthetic efficiency of a crop in transforming the photosynthetic into the economic yield. Table 6 gives result that harvesting Index has correlation with increase in see rate as Akhbar-19 at a seed rate of 150kg ha^{-1}. The physiological efficiency and ability of a crop plant for converting the total dry matter into economic yield is known as harvest index.

Conclusion:

The grain yield of seed rate wheat varieties was improved by increase in seed rate from 100 kg ha^{-1} to 150 kg ha^{-1} and variety Fakhar e Bhakkar performed well among all varieties. Increasing the seed rate resulted in increase in number of tillers per m^2 and increase yield attributes. In conclusion, increase in seed rate improved the grain yield of wheat by increasing the number of productive tillers per m^2 which could be grown to improve the wheat productivity under Thal area.

References

Afzal, S., A. Shehzad, M. A. Randhawa, A. Asghar, M. Shoaib and M. A. Jahangir. 2013. Health Benefits and Importance of Utilizing Wheat and Rye. Pakistan Journal of Food Sciences, 23: 212-22.

Akmal, M., S.M. Shah, M. Asim and M. Arif, 2011. Causes of yield reduction by delayed planting of hexaploid wheat in Pakistan. Pak. J. Bot., 43: 2561–2568.

Ayub, M., Khan, N. A., & Haider, R. Z. (2022, March). Wheat Crop Field and Yield Prediction using Remote Sensing and Machine Learning. In 2022 2nd International Conference on Artificial Intelligence (ICAI) (pp. 158-164). IEEE.

Azmeraw, B. (2022). Effect of Blended Nps and Cattle Manure Fertiizer Rates on Growth and Yield of Dry Hot Pepper (Capsicum Annum L.) in Jabi Tehnan District of Amhara Region, Ethiopia (Doctoral dissertation).

Chauhdary, J.N., U.D. Khan, S.H.H. Shah, M.A. Shahid and M. Arsalan. 2016. Effect of sowing methods and seed rates on wheat yield and water productivity. Qual. Assur. Saf. Crops Foods. 8(2): 267-272.

FAO (Food and Agriculture Organization of the United Nations). 2005. FAOSTAT [Online].Available at http://www.fao.org/faostat cited 24 Feb. 2005; verified 14

Hochman, Z., & Horan, H. (2018). Causes of wheat yield gaps and opportunities to advance the water-limited yield frontier in Australia. Field Crops Research, 228, 20-30.

Hussain, I., A. Ali, A. Ahmed, H. Nasrullah, S. Iqbal, A.M. Aulakh, J. Akhter and G. Ahmed. 2018. Impact of ridge-furrow planting in Pakistan: empirical evidence from the farmers field. Int. J. Agron. 2018: 3798037.

Hussain, M., M. Farooq, G. Shabir, M.B. Khan and A.B. Zia, 2012a. Delay in planting decreases wheat productivity. Intl. J. Agric. Biol., 14: 533539.

Jámbor, A., Czine, P., & Balogh, P. (2020). The impact of the coronavirus on agriculture: first evidence based on global newspapers. Sustainability, 12(11), 4535.

Malik, A.U., M. Ahmad and I. Hussain, 2009. Effect of seed rates sown on different dates on wheat under agro-ecological conditions of Dera Ghazi Khan. J. Anim. Plant Sci., 19: 126–129.

Melash, A. A., Mengistu, D. K., Aberra, D. A., & Tsegay, A. (2019). The influence of seeding rate and micronutrients foliar application on grain yield and quality traits and micronutrients of durum wheat. Journal of Cereal Science, 85, 221-227.

Nadeem, M. 2001. Growth, radiation use efficiency and yield of some new wheat cultivars under variable nitrogen rates, University of agriculture.

Naveed, K., M. A. Khan, M. S. Baloch, K. Ali, M. A. Nadim, E. A. Khan, S. Shah and M. Arif. 2014. Effect of different seeding rates on yield attributes of dual-purpose wheat. Sarhad journal of agriculture, 30.

Olesen, J.E., M. Trnka, K.C. Kersebaum, A.O. Skjelvåg, B. Seguin, P. Peltonen-Sainio, F. Rossi, J. Kozyra and F. Micale, 2011. Impacts and adaptation of European crop production systems to climate change. Eur. J. Agron., 34: 96–11.

Said, A., H. Gul, B. Saeed, B. Haleema, N.L. Badshah and L. Parveen, 2012. Response of wheat to different planting dates and seeding rates for yield and yield components. ARPN J. Agric. Biol. Sci., 7: 138–140.

Sánchez, M. V., Cicowiez, M., & Ortega, A. (2022). Prioritizing public investment in agriculture for post-COVID-19 recovery: A sectoral ranking for Mexico. Food Policy, 109, 102251.

Sarker, M.A.Z., Malaker, P.K., Bodruzzaman, M., Barma, N.C.D., 2009. Effect of management and seed rate on the performance of wheat varieties with varying seed sizes. Bangladesh J. Agr. Res., 34(3), 481-492.

Shah, K. K., Modi, B., Pandey, H. P., Subedi, A., Aryal, G., Pandey, M., & Shrestha, J. (2021). Diversified crop rotation: an approach for sustainable agriculture production. Advances in Agriculture, 2021.

Susskind, D., & Vines, D. (2020). The economics of the COVID-19 pandemic: an assessment. Oxford Review of Economic Policy, 36(Supplement_1), S1-S13.

Ullah, H., Santiago-Arenas, R., Ferdous, Z., Attia, A., & Datta, A. (2019). Improving water use efficiency, nitrogen use efficiency, and radiation use efficiency in field crops under drought stress: A review. Advances in agronomy, 156, 109-157.

Yadav, S. S., Hegde, V. S., Habibi, A. B., Dia, M., & Verma, S. (2019). Climate change, agriculture and food security. Yadav SS, Redden RJ, Hatfield JL, et al., DH (ed) Food security and climate change, First Edit. John Wiley & Sons Ltd.