ORIGINAL RESEARCH

Unprecedented response of wheat to irrigation levels and various rates of Nano-black carbon

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ABSTRACT

In Khyber-Pakhtunkhwa, Pakistan, wheat yield is subjected to the availability of water and the proper rate of Nano-black carbon in the soil. Delay in the rain and unsuitable soil health cause severe yield reduction. Therefore this experiment was conducted to compare irrigation levels in relation to a different rate of Nano-black carbon to find out the high yielding fact that could enhance wheat productivity and food security. Three different irrigation levels (250-mm, 275-mm and 300-mm), were compared in early growth stages with five different rates of Nano-black carbon (5Mg ha^{-1}, 10Mg ha^{-1}, 15Mg ha^{-1}, 20Mg ha^{-1} and 25Mg ha^{-1}). All other agronomic practices were kept similar for each replication. Data was recorded on different growth parameters such as days to emergence, emergence m^{-2}, plant height, spike length, number of spikes m^{-2}, thousand-grain weight and grain yield. The study confirmed that almost all irrigation levels were prominent but a significant reduction in different parameters was observed with variation in Nano-black carbon that could ultimately affect soil health and productivity. It was concluded that the proper rate of Nano-black carbon can significantly enhance the development of the roots system which may ultimately increase the shoot growth and final yield. Wheat irrigation levels (250 mm) can properly save water and increase wheat productivity in combination with Nano-black carbon amendments.

KEYWORDS: Wheat (*Triticum aestivum* L.), Nano-black carbon, growth, yield, drought, irrigation regimes

1. INTRODUCTION

Wheat (*Triticum aestivum L.)* belongs to the family *Gramineae* and is consumed as a major grain crop of the world (Imran, 2021a). It is also known as the king of cereal and supplies about 60% of the calories and protein of the average diet (Khalil and Jan, 2012). It is ranked 1st among other cereal crops in Pakistan and occupies about 66% of the annual food cropped area (Anonymous, 2012). In Pakistan, wheat is grown on an area of 9204 thousand hectares with an annual production of 9260 thousand hectares with an average yield of 2752kg ha^{-1} (Tunio et al. 2016). Despite higher yield potential, the average yield of wheat in Pakistan is low as compared with advanced countries (Imran, 2021a; Imran et al., 2021a; Imran et al., 2020a). Several factors are responsible for the low productivity of wheat in Pakistan like edaphic factors, cultural practices, genetic factors and environmental conditions. In the current scenario, improved cultural practices and proper nutrient management are the major issues in wheat production. In Pakistan wheat are raising under both, irrigated and rain-fed condition, whereas in Khyber Pakhtunkhawa, almost 70% of wheat is grown under rainfed condition(Imran, 2015a; Imran, 2021b; Imran et al., 2021c). Efforts are in progress to breed for high yield, better protein quality, biotic and abiotic stresses resulting in the development of many cultivars (Al-Maskri et al., 2012). Irrigation levels having the potential for early seedling vigor use available soil water efficiently, resulting in better dry matter accumulation and higher grain yield (Awan et al.,2005). The best irrigation level allows the cropto produce a higher yield under unfavorable conditions (drought, salinity and extreme temperature) (Imran et al., 2020b; Imran et al., 2018; Imran et al., 2021b).

Grain yield of wheat can be reduced with the reduction in irrigation level, whereas the addition of biochar might improve water use efficiency and plant essential nutrients uptake (Jan et al., 2012). Previously it is reported that biochar with different irrigation regimes may show high efficiency and booted yield (Ali et al., 2020; Ali et al., 2021; Imran et al., 2020c; Imran et al., 2021d; Imran et al., 2021e; Imran, 2015b). Donaldson et al. (2013) reported that irrigation regimes resulted in increased wheat straw production and generally higher grain yield compared with various carbon sources. Furthermore, Patel et al. (2010) and Aslam et al. (2013) tested newly introduced irrigation levels, concerning yield and observed that the highest yield (5484kg ha^{-1}) was obtained with the integration of organic sources and the highest irrigation level (Tunio et al. 2016). Likewise, yield reduction of 27% and 52% was noted by Ali et al. (2014) when wheat crop was sown with and without organic amendments. In addition, Tahir et al. (2011) concluded that regardless of irrigation levels, better yields were obtained when wheat was treated with organic sources application before irrigation. Shah and Akmal (2002) reported that grain yield decreased by 28 percent when irrigation was delayed by 45 days in the season. Furthermore, early irrigation favored in high tillering and ultimately in respect of grain and biological yield.

The current study aimed to investigate the effects of different irrigation levels with five different Nano-black carbon rates on wheat crop growth parameters such as days to emergence, emergence m^{-2}, plant height, spike length, number of spikes m^{-2}, thousand-grain weight and grain yield. Furthermore, we aimed to evaluate the suitable level of Nano-black carbon under less irrigation to find out the high yielding fact that could enhance wheat productivity and food security

2. MATERIALS AND METHODS

2.1 Experimental Site

Wheat performance under different irrigation levels and various rates of Nano-black carbon for grain yield was studied under field conditions during the winter season of 2018-19 and 2019-20. The soil of the experimental site was clay loam with less organic matter and slightly acidic. Experiments were conducted in Randomized Complete Block Design with split plots arrangement having three replications. Nano-black carbon was allotted to the main plots while Irrigation levels were assigned to sub-plots. Each experimental unit was 1.5 m x 3.3, accommodating 11 rows equally spaced at 30cm. Initially, all sowings were done at a uniform seeding rate at the rate of 100 kg ha^{-1}. However, the desired population was maintained by manual thinning. Phosphorous at the rate of 90 kg ha^{-1} was applied in the form DAP. All the phosphorous and ½ of the nitrogen was applied at the time of sowing and Nano-black carbon was applied at the time of seedbed preparation. The remaining ¼ nitrogen was top-dressed with first irrigation and ¼ with second irrigation. The crop was sown on a well-prepared seedbed using a seed rate of 120 kg ha^{-1}. All other agronomic practices were kept normal and uniform for all the treatments

Following factors were studied during the experiment, Nano-black carbon were applied to the main plot at the rate of 5 Mg ha^{-1}, 10 $Mgha^{-1}$,15 Mg ha^{-1}, 20 Mg $ha^{-1}$and 25 Mg ha^{-1}while irrigation level were treated to sub-plots at the rate of 250 mm, 275 mm and 300 mm respectively.

2.2 Procedure for Recording Data

Data regarding days to emergence was recorded by counting the days taken from the date of sowing to the date when 50% emergence occur in each plot. Data on emergence m^{-2} was recorded in two central rows by using the following formula. Data on the number of tillers was recorded by counting the numbers of tillers in central two rows of each plot and was then converted into numbers of tillers m^{-2}. Data on plant height was recorded by measuring randomly selected 10 plants in each plot from the base of the plant to the tip of spikes excluding awns at physiological maturity. Data on spike length was recorded by using a plastic scale of length 30cm.Data regarding grain $spike^{-1}$ was recorded by counting wheat grains in randomly selected five spikes in each plot and was averaged accordingly. Data on grain yield was recorded by harvesting the two central rows in each plot and was sun-dried, weighed, and then converted to kg ha^{-1}. Data regarding thousand grains weight was recorded on the sensitive electronic balance after counting a thousand grains for each plot.

2.3 Statistical Analysis

The recorded data were statistically analyzed according to the analysis of variance techniques used for randomized complete block design and the least significant difference (LSD) was used at a 5% level of significance ($P \leq 0.05$) upon significant F-test through the procedure described by Jan et al. (2009).

3. RESULTS AND DISCUSSION

3.1 Days to Emergence (m^{-2})

Data regarding days to emergence (DE) in response to different irrigation levels and Nano-black carbon showed significant differences in emergence timing (Table 1). Earlier emergence was noted with 5 Mg ha^{-1}followed by 10 Mg $ha^{-1}$and 15 Mg ha^{-1} having at par values while delayed emergence was recorded with 25 Mg ha^{-1}followed by 20 Mg ha^{-1}respectively (Fig 1). The reason for emergence deviation might be due to environmental factors which influence enzyme activation and rupturing of seed coat and ultimately seed emergence. The optimum temperature activates most of the enzymes in aleoron layer of the seed coat which activates the embryo of the seed and leads to early emergence. The possibility of early emergence in 5 Mg ha^{-1} might be due to optimum temperature in field conditions and enhanced emergence as compared to other Nano-black carbon. The delayed emergence might be due to environmental stress in which seeds do not react well and become dormant due to harsh components of the environment (minimum temperatures, rainfall, humidity, winds and sunshine, etc) and may take more days to emergence. Similarly, in the case of wheat Irrigation levels, earlier emergence was produced by 275mm irrigation followed by 250 mm irrigation level whereas the delayed emergence was noted 300 mm irrigation. This might be the genetic character of the variety and leading to early or late emergence. These results are in connection with the findings of Imran et al. (2020) who reported that differences in the total roots of a young seedling of different wheat Irrigation levels were affected by different moisture levels and Irrigation levels. While their interactions were non-significant. These results are supported by Shah et al. (2011) who reported that reduction in moisture content reduces the seminal root length. The difference in root length is the cause of survival of a seedling in stresses and its re-growth potentials under abnormal situations. The better the root grows with a relatively longer length may result inthe better establishment of the seedling and withstand against abnormal situations e.g. drought, high temperatures and salt stress to convert the seedling to a healthy plant for production (Khan et al., 2014).

3.3 Emergence (m^{-2})

Data regarding emergence per m^{-2} of different wheat Irrigation levels (Table 2) showed significant differences in seedling emergence of different wheat Irrigation levels as affected by different Nano-black carbon. More seedlings were counted with seeds sown on 20 Mg ha^{-1} followed by 5 Mg ha^{-1} and 15 Mg ha^{-1} having at par values while less number of emerged seedlings were counted with 10Mg ha^{-1} and then by 25 Mg ha^{-1} respectively (Fig 2). The reason for emergence deviation might be due to environmental factors which influence enzyme activation and rupturing of seed coat and ultimately seed emergence.

The optimal temperature activates the majority of the enzymes in the aleoron layer of the seed coat, wakes up the embryo of the seed, and results in early emergence. When compared to other Nano-black carbon rates, the prospect of early emergence in 5 Mg ha^{-1}

Table 1. Days to emergence as influenced by different Nano-black carbon rates and irrigation levels (Data pooled over the both years)

Nano-black carbon (Mg ha^{-1})	Irrigation levels			Mean
	250 mm	275 mm	300 mm	
5	7.333	6.333	7.333	7.000d
10	9.000	10.333	9.333	9.556c
15	9.000	9.333	9.333	9.222c
20	12.333	10.000	11.333	11.222b
25	20.667	21.333	24.667	22.222a
	11.667ab	11.467b	12.400a	

LSD value ($P \leq 0.05$) for Irrigation levels = 0.6
LSD value ($P \leq 0.05$) for Nano-black carbon = 0.8

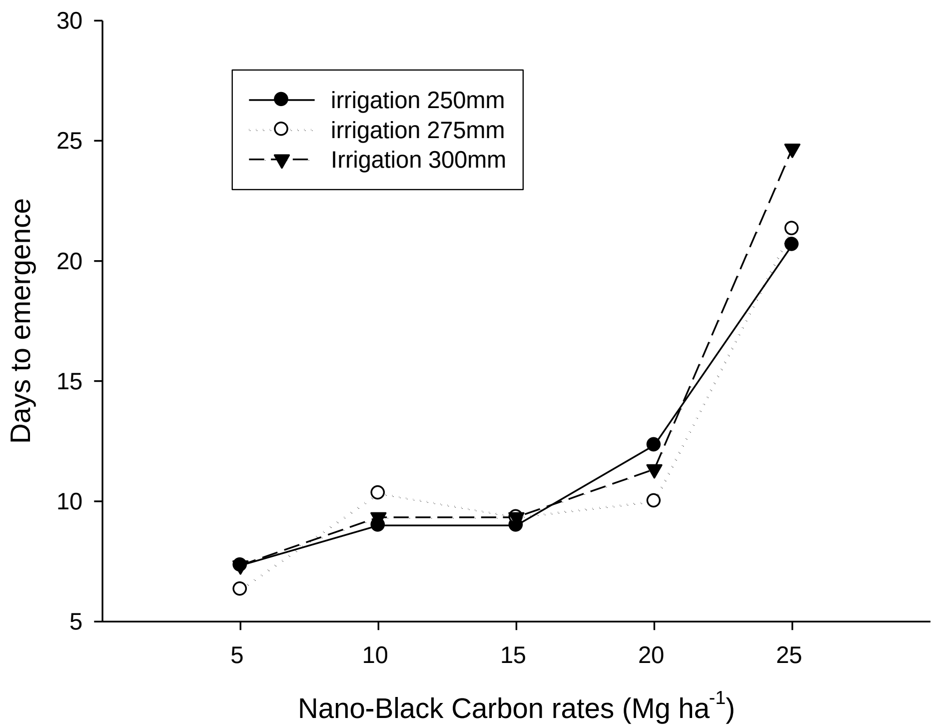

Figure 1. Response of days to emergence to different irrigation levels and Nano-black carbon

may boost emergence. The emergence may be due to environmental stress, in which seeds do not react effectively and go latent as a result of severe environmental components, and it may take additional days for the seeds to emerge. Similarly, more seedlings were counted with 250mm irrigation, followed by 275mm irrigation, however minimal emergence (m-2) was found with 300mm irrigation having statistically equal values with 275mm irrigation. This might be due to the genetic characteristics of the variety, resulting in early or late emergence. Different moisture levels and Irrigation levels have an impact on Irrigation levels. Even though their encounters were insignificant. According to literature, the root is the most important part of a plant and has strived to be the best until the availability and search for water to support plant development (Ozham and Hajibabaei, 2014). The more roots a plant has, the healthier it is, the better it can withstand drought and wind, and the seedling has a better chance of survival. Our findings are confirmed by the findings of Abdoli and Saeidi (2012), who revealed that decreasing the moisture level reduces the radical weight of different wheat irrigation levels. Water stress inhibits the mobilization of starchy endosperm in various species (Bouaziz and hicks 1990). Increasing early growth has the potential to increase soil N (Pang et al., 2014) and P (Ryan et al., 2014) absorption, hence improving crop nutrient-use efficiency and weed competitiveness (Coleman et al., 2001).

3.4 Number of Tillers (m^{-2})

Data on the number of tillers per m-2 revealed substantial changes in the number of tillers per m-2 of different irrigation levels as impacted by varied Nano-black carbon concentrations (Table 3). The different Nano-black carbon effect was non-significant for the number of tillers m^{-2} showing statistically at par value for all Nano-black carbon. The Irrigation levels effect was significant and more tillers were counted with 275 mm irrigation followed by 250 mm irrigation whereas the tinniest tillers m^{-2} were recorded with 300 mm irrigation (Fig 3). Another possible reason could be due to environmental factors which influence enzyme activation. The optimum temperature may enhance plant growth and development. The possibility might be due to optimum temperature in field conditions and enhanced plant lateral growth and branches initiations. These results are in connection with the findings of Imran et al. (2020) who reported that differences in the total roots of a young seedling of different wheat irrigation levels were affected by different moisture levels and Irrigation levels. While their interactions were not significant.

The possible reason could be increased early growth has the potential to increase soil N (Pang et al., 2014) and P (Ryan et al., 2014) absorption, hence improving crop nutrient-use efficiency and weed competitiveness (Coleman et al., 2001).

Table 2. Emergence m^{-2} as influenced by different Nano-black carbon rates and irrigation levels (Data pooled over the both years).

Nano-black carbon (Mg ha^{-1})	Irrigation levels			Mean
	250 mm	275 mm	300 mm	
5	188.33	135.00	139.00	154.11a
10	77.00	83.67	62.00	74.22b
15	128.00	105.33	73.67	102.33b
20	200.67	166.00	158.67	175.11a
25	104.00	87.33	110.00	100.44b
	139.60a	115.47b	108.67b	

LSD value ($P \leq 0.05$) for wheat Irrigation levels = 0.7
LSD value ($P \leq 0.05$) for Nano-black carbon = 0.9

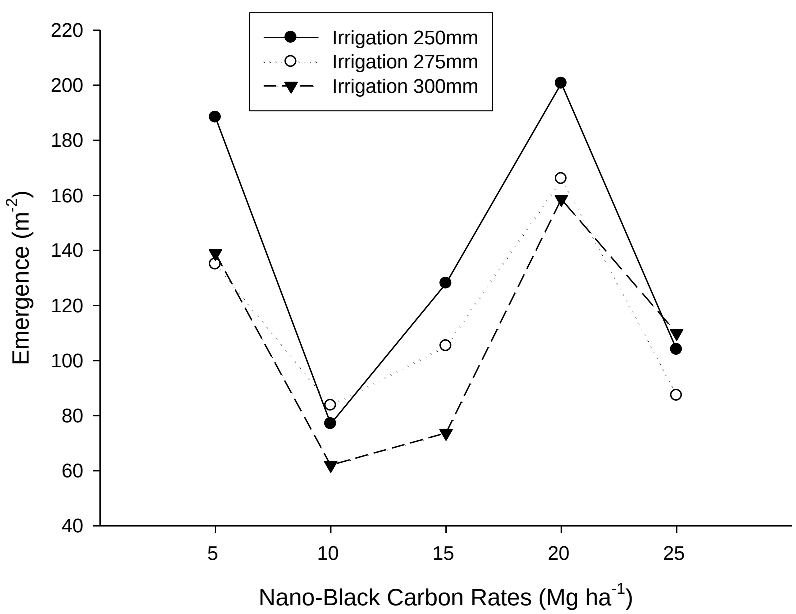

Figure 2. Response of emergence $m^{-2}$to different irrigation levelsandNano-black carbon

More robust crops collect more light, maximizing crop growth rates and biomass, especially with late planting or in settings with shorter crop duration (Takahashi and Gotoh, 1996; Regan et al., 1997). Appropriate variety selection based on seedling performance is thus essential for higher yield and crop growth under abnormal conditions, such as drought stress, which is most commonly encountered by wheat crop in the country as well as in the province where more than 66 percent of the area is rain-fed.

3.5 Plant Height (cm)

Data regarding plant height (Table 4) divulge that the highest plant height was recorded with 10 Mg ha^{-1} followed by statistically similar values of 15 Mg ha^{-1} and 5 Mg ha^{-1}. The dwarf plants were produced when the wheat Irrigation levels were sown on 25 Mg ha^{-1} and 20 Mg ha^{-1} respectively. Among the irrigation levels, the highest plant height was noted in irrigation level of 300 mm followed by 250 mm having statistically similar values. The lowest plant height was produced by 275 mm irrigation rate respectively. The possibility might be due to optimum temperature in field conditions and enhanced emergence as compared to other Nano-black carbon (Fig 4). The explanation might be related to environmental fluctuations in temperature, rainfall, humidity, and so on, which cause extra days to develop. Similarly, more seedlings were counted with 50 mm irrigation level, followed by 275 mm, although minimal emergence (m-2) was detected with 300 mm irrigation level having statistically identical values with 275 mm. This might be due to the genetic characteristics of the variety, resulting in early or late emergence. These findings are consistent with those of Imran et al. (2020), who discovered that variations in the total roots of a young seedling of various wheat Irrigation levels were influenced by moisture and Irrigation levels. Even though their encounters were insignificant. Variety Hashim-08 has the greatest root number in the group, followed by Pak-2013, DN-84, and Pirsabak-2005. While Kpk-2015 has the lowest amount of roots reported. It is reported that root is the fundamental portion of a plant and has striven to the best till the availability and search of water to sustain plant growth (Ozham and Hajibabaei, 2014). When the quantity of roots rises, the crop becomes more resilient to drought and wind, and the seedling has a better chance of surviving even when less water is available. More vigorous crops collect more light, maximizing crop growth rates and biomass, especially when planting late or in settings where crop duration is limited (Takahashi and Gotoh, 1996; Regan et al., 1997). Appropriate variety selection based on seedling performance is thus essential to be taken into account for higher yield and crop growth under abnormal circumstances, such as drought stress, which is most commonly faced by wheat crops in the country as well as in the province where more than 66 percent of the area is rain-fed.

3.6 Spike Length (cm)

Mean values of the data revealed that the highest spike length was recorded with 15 Mg ha^{-1} followed by statistically similar values of 5 Mg ha^{-1} and 10 Mg ha^{-1}(Table 5). Minimum spike length was recorded in those plots which were sown on 25 Mg ha^{-1} or either 20 Mg ha^{-1}. Among the Irrigation levels, lengthy spikes were produced with 300 mm followed by statistically similar 250 mm and 275 mm irrigation levels (Fig 5). The possibility might be due to optimum temperature in field conditions and enhanced emergence as compared to other Nano-black carbon.

Table 3. Number of tillers m^{-2} as influenced by different Nano-black carbon rates and irrigation levels (Data pooled over the both years).

Nano-black carbon ($Mg\ ha^{-1}$)	Irrigation levels			Mean
	250 mm	275 mm	300 mm	
5	200.33	229.33	144.67	191.44
10	184.00	223.00	140.67	182.56
15	171.00	233.00	148.33	184.11
20	191.33	184.00	187.67	187.67
25	217.33	179.33	169.67	188.78
	192.80ab	209.73a	158.20c	

LSD value ($P \leq 0.05$) for wheat Irrigation levels = 10.3
LSD value ($P \leq 0.05$) for Nano-black carbon = 11.2

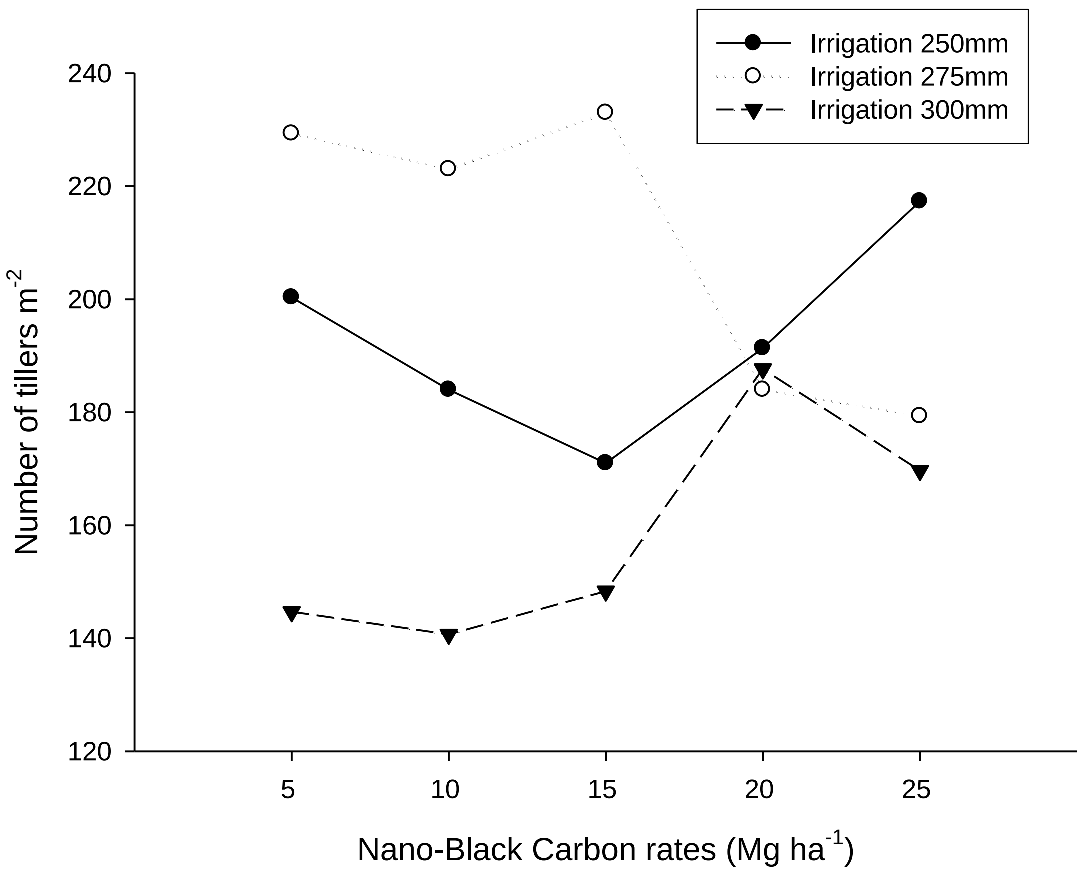

Figure 3. Response of number of tillers m^{-2} to different Irrigation levelsandNano-black carbon

Table 4. Plant height (cm) as influenced by different Nano-black carbon rates and irrigation levels (Data pooled over the both years).

Nano-black carbon (Mg ha^{-1})	Irrigation levels			Mean
	250 mm	275mm	300 mm	
5	101.83	90.32	94.30	95.48ab
10	107.21	97.42	112.75	105.79a
15	90.51	94.95	107.54	97.67ab
20	92.11	92.11	96.77	93.66b
25	86.52	80.65	92.72	86.63b
	95.64ab	91.09b	100.82a	

LSD value (P≤ 0.05) for wheat Irrigation levels = 10.3
LSD value (P≤ 0.05) for Nano-black carbon = 11.2

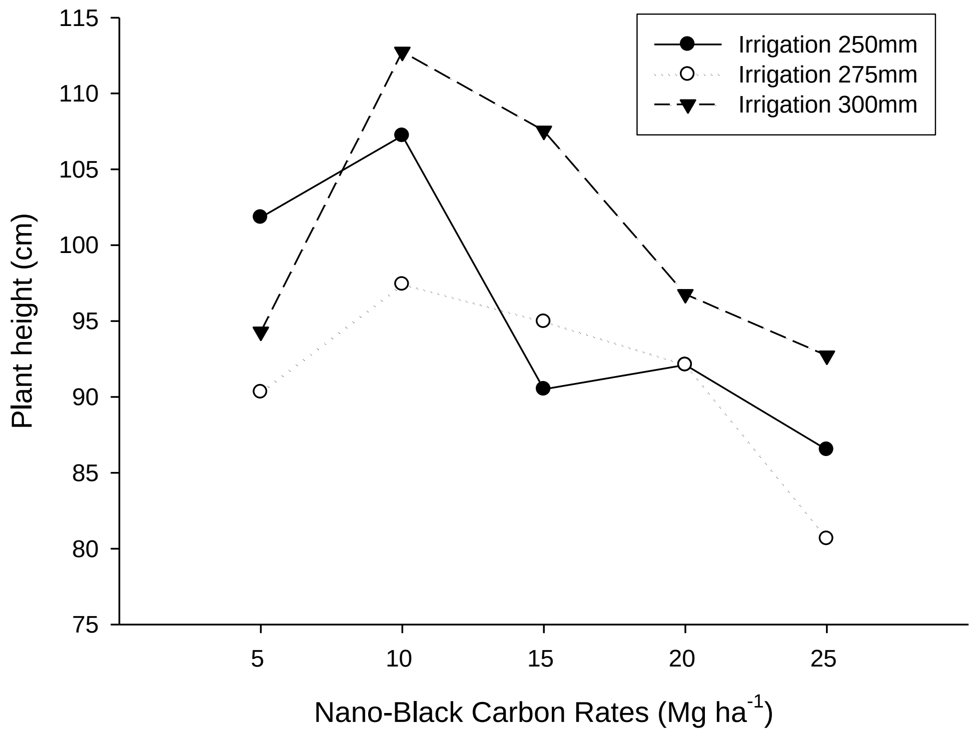

Figure 4. Response of plant height to different irrigation levels and Nano-black carbon

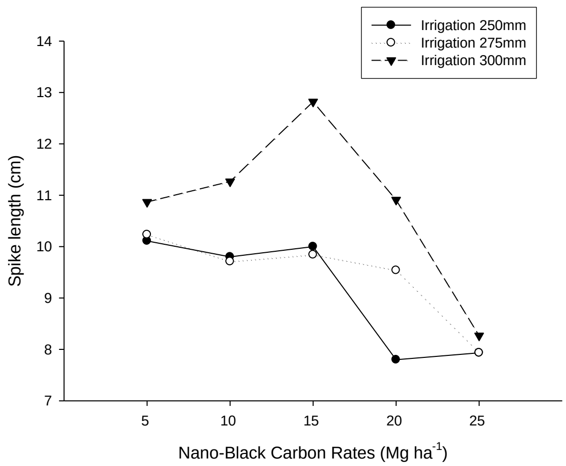

Figure 5. Response of spike length to different Irrigation levels and Nano-black carbon.

The enlarged plant might be attributed to temperature, and similarly, more seedlings were counted with 250 mm irrigation, followed by 275 mm, and the least emergence (m-2) was reported with 300 mm irrigation. These findings are consistent with the findings of Imran et al. (2020), who discovered variances in the total roots of early seedlings of different wheat varieties. Different moisture levels and Irrigation levels affectedthe irrigation levels. While their encounters were insignificant. Increasing crop nutrients, vigorous crop growth, and biomass have the potential to boost crop nutrients, vigorous crop growth, and biomass, especially with late planting or in conditions where crop duration is shorter. Drought stress is the most prevalent problem that wheat faces and 66 percent of the area are used to support plant development.

3.6 Thousand Grain Weight (g)

Data regarding thousand-grain weight of different wheat Irrigation levels as influenced by different Nano-black carbon(Table 6). The mean values divulge that more thousand-grain weight was produced by those plots which were sown on 5 Mg ha^{-1} followed by 10Mg ha^{-1} whereas minimum thousand seed weight was recorded with 20 Mg ha^{-1} followed by 15 Mg ha^{-1} and 25 Mg ha^{-1} respectively (Fig 6). The Irrigation levels were non-significant for thousand seed weight and noted that all the cultivars produced statistically similar thousand-grain weight. The fluctuation in thousand-grain weight with different Nano-black carbon might be due to optimum temperature in field conditions and enhanced emergence as compared to other Nano-black carbon. Plant phenology can be improved by using nano-black carbon and irrigation. These findings are related to the work of Imran et al. (2020), who discovered that variances in the total roots of a young seedling were impacted by varying moisture levels.

Biochar increases soil N and P to improve crop nutrient utilization efficiency and weed competitiveness (Coleman et al., 2001). In the case of Irrigation levels comparison, the highest grain yield was recorded with the sowing of the cultivar 250 mm followed by 300 mm having statistically similar produce. More vigorous crops collect more light, maximizing crop growth rates and biomass, especially when planting late or in settings where crop duration is limited (Takahashi and Gotoh, 1996; Regan et al., 1997).

Table 5. Spike length (cm)as influenced by different Nano-black carbon rates and irrigation levels (Data pooled over the both years).

Nano-black carbon (Mg ha^{-1})	Irrigation levels			Mean
	250 mm	275mm	300 mm	
5	10.110	10.233	10.867	10.403ab
10	9.800	9.710	11.267	10.259ab
15	10.00	9.843	12.820	10.888a
20	7.800	9.537	10.910	9.416b
25	7.933	7.933	8.267	7.857c
	9.129b	9.339b	10.826a	

LSD value (P≤ 0.05) for wheat Irrigation levels = 10.3
LSD value (P≤ 0.05) for Nano-black carbon = 11.2

Table 6. Thousand grain weight (g) as influenced by different Nano-black carbon rates and irrigation levels (Data pooled over the both years).

Nano-black carbon (Mg ha^{-1})	Irrigation levels			Mean
	250 mm	275 mm	300 mm	
5	46.667	53.333	46.667	48.889a
10	46.667	33.333	40.000	40.000b
15	33.333	30.000	36.667	33.33bc
20	33.333	33.333	30.000	32.222c
25	36.667	33.333	30.000	33.333bc
	39.333a	36.667a	36.667a	

LSD value (P≤ 0.05) for wheat Irrigation levels = 10.3
LSD value (P≤ 0.05) for Nano-black carbon = 11.2

Table 7. Grain yield (kg ha^{-1}) as influenced by different Nano-black carbon rates and irrigation levels (Data pooled over the both years).

Nano-black carbon (Mg ha^{-1})	Irrigation levels			Mean
	250 mm	275 mm	300 mm	
5	4404.2	4579.3	4656.2	4546.6 a
10	3757.6	1777.8	3609.2	3048.2 b
15	3339.9	1764.2	1670.1	2258.1 bc
20	2122.6	1631.0	1973.3	1908.9 cd
25	1710.6	888.7	1333.4	1310.9 d
	3067.0a	2128.2b	2648.4ab	

LSD value (P≤ 0.05) for wheat Irrigation levels = 10.3

LSD value (P≤ 0.05) for Nano-black carbon = 11.2

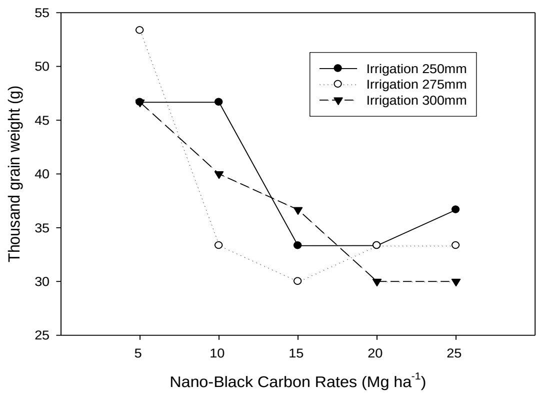

Figure 6. Response of thousand-grain weight to different Irrigation levels and Nano-black carbon

Appropriate variety selection based on seedling performance is thus essential to be taken into account for higher yield and crop growth under abnormal circumstances, such as drought stress, which is most commonly faced by wheat crop in the country as well as in the province where more than 66 percent of the area is rain-fed. Despite the fact that their encounters were insignificant.

3.7 Grain Yield (kg ha^{-1})

Data regarding grain yield of different wheat Irrigation levels as influenced by different Nano-black carbon (Table 7). Mean data revealed that the highest wheat grain yield was produced by those plots which were sown on 5 Mg ha^{-1} Followed by 10 Mg ha^{-1} having at par value with 15 Mg ha^{-1}. The lowest grain yield was produced when the plots were sown on 25 Mg ha^{-1} followed by 20 Mg ha^{-1} respectively (Fig 7). The lowest grain yield was noted with the sowing of the cultivar 275 mm. Generally, it was concluded that the most productive cultivar was 250 mm having the supreme grain yield as compared to other sown cultivars.

Among the Nano-black carbon, either 5 Mg ha^{-1}for wheat production was noted the outmost promising factor to overcome on food hunger and inconsistency.

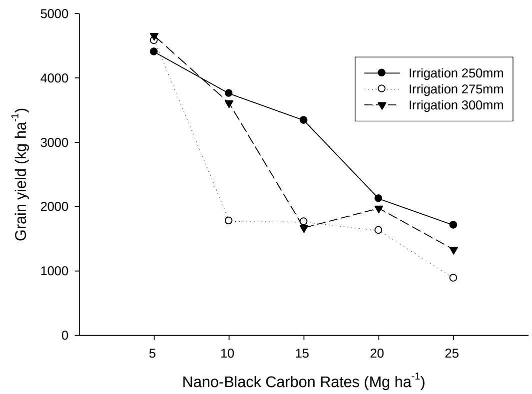

Figure 7. Response of grain yield to different Irrigation levelsandNano-black carbon

Imran et al. (2020) stated that plant phenology may be enhanced by employing Nano-black carbon and watering. They also demonstrated that more vigorous crops are taken into account for greater yield and crop growth in atypical situations. Variety Hashim-08 has the greatest root number of the bunch, followed by Pak-2013, DN-84, and Pirsabak-2005. While Kpk-2015 has the fewest roots. According to reports, the root is the most important part of a plant and has strived to be the best until the availability and search for water to support plant development (Ozham and Hajibabaei, 2014). The bigger the root number, the healthier the plant, the better it will be able to withstand drought and wind, and the seedling will have a better chance of survival if water is made accessible at any stage throughout the crop's growth.

4. CONCLUSION

According to the findings of this study, a correct rate of Nano-black carbon can considerably improve the development of the root system, which may ultimately boost shoot growth and final yield. The current investigation found that wheat Irrigation levels (250 mm) may germinate properly even at low moisture and varying rates of Nano-black carbon. Variation in sowing date decreases growth and other yield-related qualities in a linear fashion. Different Irrigation levels responded differently to different Nano-black carbon, indicating that there is potential for additional development in genotype. It is necessary to develop such irrigation levels that can be grown in every environment and have changeable Nano-black carbon capacity to resist diverse environmental influences.

Data Availability statements: The data presented in this study are available on request from the corresponding author.

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Conflicts of Interest: The authors declare no conflict of interest.

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