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Response of varieties and growth regulators on yield and economics of wheat (*Triticum aestivium* L.)

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Abstract
An experiment was conducted at the Zonal Agricultural Research Station, JNKVV, Powarkheda, Narmadapuram, during the *rabi* season of 2021 and 2022 to examine the response of wheat varieties to varied levels of cycocel and ethephon treatment. The experiment was carried out in a split-plot design having two factors having three replications. In the main plot, four varieties were taken, namely GW 322, Sujata, C 306 and MP 1202, in the subplot, two growth regulators were taken, *viz*. control, cycocel @ 1000 ppm and 1500 ppm and ethephon @ 10 ppm and 30 ppm. It was observed from the data that both varieties and growth regulators had a significant effect on the yield and economics of wheat. Among varieties, it was observed that MP 1202 was statistically superior in effective tiller (599.24 m^{-2}), grains per earhead (44.49), grain yield (51.61 q ha^{-1}), and straw yield (72.00 q ha^{-1}). Variety MP 1202 also resulted in higher grass return (Rs 94975 ha^{-1}), net return (Rs 50432 ha^{-1}) and benefit cost ratio (2.12). Among growth regulators, it was observed that cycocel @ 1500 ppm resulted in significantly higher effective tiller (538.43 m^{-2}), grains per earhead (44.15), grain yield (49.99 q ha^{-1}), and straw yield (73.12 q ha^{-1}), further resulting in superior gross return (Rs 94911 ha^{-1}), net return (Rs 49248 ha^{-1}), and benefit-cost ratio (2.08).

Keywords: Wheat variety, growth regulators, yield attributes, yield and economics

Introduction
Wheat (*Triticum aestivum* L.) is one of the largest-growing cereal crop in the world and plays an important role in the food and nutritional security of a large part of the global population in the food basket. Wheat is widely cultivated across the world. India holds second rank in production and first rank in area in the global place. Wheat is cultivated in India in 30.47 million hectares, with a production of 106.84 million tonnes with the productivity of 3507 kg per hectare in the year 2021-22 (Agricultural Statistics at a Glance, 2022) [1]. Grain yield losses are about 12-66% in wheat due to lodging. (Rajkumara, 2008) [2] in India.
Plant growth regulators (PGR) like chlormequat chloride (cycocel) and ethephon are effective in grain yield production by altering plant height and lodging incidence in wheat (Crook and Ennos, 1995) [3]. PGR applicationn has the potential to mitigate the inhibitory effects of stress on plant growth and crop productivity (Ashraf *et al*., 2008) [4]. Cycocel (CCC), or chlormequat chloride, as a synthetic growth retardant inhibits gibberellin biosynthesis via blocking 2 ent-kaurene synthesis in the metabolic pathway of gibberellin production, resulting in reduced amounts of active gibberellins and consequent reduction in stem elongation. The plant growth regulator ethephon, a key source of ethylene, effectively reduces plant height and lodging when applied to cereal crops. In cereals, the effect of ethephon on grain yield has also been observed along with the reducing effect on plant height (Boutaraa, 1991) [5]. Plant growth regulators such as cycocel and ethephon, play a crucial role in the modification of crop growth and development. However, limited studies are available on their effect on wheat cultivars in the Central Narmada Valley. Therefore, the present study was undertaken to investigate the response of varieties and growth regulators on the yield and economics of wheat.

Materials and Methods
Powarkheda is situated in the Central Narmada Valley of the agroclimatic zone of Madhya Pradesh. This centre is situated at 77°42' N latitude, 22°40' E longitude and 299 m above mean

sea level altitude. The climate is characterised as typically tropical sub-humid, which is hot and dry in summer and cool and dry in winter. The meteorological data on temperature, rainfall, relative humidity and sunshine hours were recorded during the course of study from November to April in 2020-21 and in 2021-22 at the Zonal Agricultural Research Station, Meteorological Observatory, Powarkheda, Narmadapuram. In 2020-21, weekly maximum temperature varied from 18.36 °C to 40.24 °C, while minimum temperature varied from 6.93 °C to 20.64 °C. The maximum temperature varied from 18.91 °C to 42.56 °C during the year 2021-22, while the minimum temperature varied from 5.2°C to 23.03°C. The relative humidity was 88.56% in the morning and 32.36% in the evening in the 1st year, while in the 2nd year of experimentation it was 87.86% in the morning and 29.73% in the evening. The total rainfall was 90 mm in the first year and 52 mm in the second year. No weather abnormalities were recorded during the entire crop season. The soil texture is deep black having a neutral soil pH value, containing 49.26% sand, 24.24% silt and 26.50% clay. The organic carbon content was 0.48% and the soil was low in available N (95 kg ha^{-1}), medium in available P (21.72 kg ha^{-1}) and high in available K (300.26 kg ha^{-1}).

The experiment was designed in a split plot with four wheat varieties, namely GW 322, Sujata, C 306 and MP 1202, as the main plot and different growth regulators in various levels (cycocel @1000 ppm, cycocel @1500 ppm, ethephon @ 10 ppm, ethephon @ 30 ppm and control) were applied in sub-plots with three replications. The nutrients nitrogen, phosphorus, and potassium (N:P:K) were applied at a rate of 120:60:40 kg ha^{-1} using diammonium phosphate, urea, and muriate of potash, respectively. Half of the nitrogen and the full doses of phosphorus and potassium were applied initially, with the remaining nitrogen being given during the 1st and 2nd irrigations. The experiment was sown on the 10th and 11th of November in the years 2021 and 2022.The experiment was sown on 10th and 11th Nov. during the year 2021 and 2022. Data were analysed using the OPSTAT software, which is accessible on the CCS Haryana Agricultural University website (Sheoran *et al*., 1998) [6].

Results and Discussion

Productivity

It was observed that variety MP 1202 recorded significantly higher effective tiller (599.24 m^{-2}) than all other varieties (Table 1). Among growth regulators, cycocel @ 1500 ppm recorded a significantly higher effective tiller (538.43 m^{-2}) than other levels of PGRs except ethephon @ 30 ppm (525.87 m^{-2}). This might be due to their better tillering capacity and adaptability and altered tiller and spikelet production, assimilate partitioning within the plant, and root growth. Similar findings were observed by Rajala and Peltonen (2001) [7]. The data on grains earhead-^{1} is presented in Table 1. Data of Table 1 showed that variety MP 1202 recorded significantly higher grains earhead^{-1} (44.49) which was at par with variety GW 322 (43.25), but among growth regulators, cycocel @ 1500 ppm recorded significantly higher grains per earhead (44.15), which was at par with ethephon @ 30 ppm (42.96). This might be due to their superior genetic potential for grain production. Similar result was noted by Rajala (2004) [8]. It was also observed that there was significant interaction between varieties and growth regulators. Data observed that 1000-grain weight did not show any significant difference among varieties; however, it was observed that variety MP 1202 recorded the highest 1000 grain weight (45.19 g) due to the inherent properties of the variety. Among growth regulators, cycocel @ 1500 ppm recorded the highest 1000 grain weight (44.38 g) and all other treatments were at par with each other. This may be due to indicating improved assimilate translocation and grain development due to PGR application.

The data regarding grain yield is presented in Table 1 and it was observed that variety MP 1202 recorded significantly higher grain yield (51.61 q ha^{-1}) than other varieties, which might be attributed to the superior yield potential of the variety. Among growth regulators, cycocel @ 1500 ppm noted significantly higher grain yield (49.99 q ha^{-1}). A higher number of effective tillers and grains per spike may be responsible for the higher grain yield of wheat. Rajala and Peltonen (2001) [9] reported a similar result. The data regarding straw yield is presented in Table 1. Variety MP 1202 observed significantly higher straw yield (72.00 q ha^{-1}) which was at par with GW 322 (70.55 q ha^{-1}), which might be attributed to the superior yield potential of the variety. Among growth regulators, cycocel @ 1500 ppm recorded significantly higher straw yield (73.12 q ha^{-1}). This might be due to its robust vegetative and reproductive growth. Such a report was given by Turk *et al*. (2002) [10].

Profitability

On a grain yield basis, the economics of wheat were calculated (Table 2) and show that variety MP 1202 fetched the maximum gross return (Rs 94975 ha^{-1}), net return (Rs 50432 ha^{-1}) and B:C ratio (2.12) as compared to the remaining varieties of wheat. Further, these findings are also confirmed by Kumar *et al.*, 2018) [11]. Among the growth regulators, higher gross return (Rs 94911 ha^{-1}), net return (Rs 49248 ha^{-1}) and B:C ratio (2.08) were obtained with the application of cycocel @ 1500 ppm in wheat. Higher yield of wheat variety MP 1202 and application of cycocel @ 1500 ppm might have been responsible for higher gross return, net return and B:C ratio.

Table 1: Yield attributes and yield as influenced by wheat variety and plant growth regulators (Pooled data of 2 years)

Treatment	Effective Tillers (m-2)	1000 grains weight(g)	Grains earhead^{-1}	Grain yield (q/ha)	Straw yield (q/ha)
Main plot -Variety					
GW 322	578.71	44.39	43.25	49.03	70.55
Sujata	397.92	42.86	37.08	37.08	56.20
C 306	423.26	42.93	39.57	39.43	59.30
MP 1202	599.24	45.19	44.49	51.61	72.00
SEm ±	5.12	0.71	0.48	0.44	0.75
CD (p=0.05)	18.05	2.50	1.69	1.55	2.66
Sub plot-Plant growth regulators					
Control	455.68	42.96	38.05	37.5	53.30
CCC @ 1000 ppm	489.49	43.63	39.87	41.43	60.63
CCC @ 1500 ppm	538.43	44.38	44.15	49.99	73.12
Ethephon @ 10 ppm	489.43	44.21	40.45	43.89	64.22

Ethephon @ 30 ppm	525.87	44.04	42.96	48.64	71.28
SEm±	5.26	0.55	0.46	0.45	0.63
CD (p=0.05)	15.22	1.59	1.34	1.32	1.83
Interaction					
SEm±	11.41	1.10	0.93	0.91	1.26
CD (p=0.05)	33.02	3.18	2.68	2.63	3.66

Table 2: Economics (Rs. ha^{-1}) as influenced by wheat variety and plant growth regulators (Pooled data of 2 years)

Treatment	Gross monetary returns (Rs ha^{-1})	Net monetary returns (Rs ha^{-1})	B:C ratio
Main plot -Variety			
GW 322	87341	42881	1.96
Sujata	69982	25439	1.57
C 306	78108	33747	1.74
MP 1202	94975	50432	2.12
Sub plot -Plant growth regulators			
Control	64438	21282	1.46
CCC @ 1000 ppm	79656	34719	1.77
CCC @ 1500 ppm	94911	49248	2.08
Ethephon @ 10 ppm	84379	40251	1.91
Ethephon @ 30 ppm	89623	45123	2.00

Conclusion

It is finally concluded from the two-year mean data that wheat variety MP 1202 along with the application of cycocel @ 1500 ppm, was found superior in terms of productivity and profitability.

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