

Original Research Article

Impact of Optimization of Fertilizer levels with Growth Regulators on Nutrient Balance in Wheat crop (*Triticum aestivum* L.)

ABSTRACT

A field experiment was conducted during the *rabi* season of 2020 at All India Coordinated Research Project (AICRP) on Wheat, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) to evaluate nutrient balance under the optimization of fertilizer levels with plant growth regulators. The experiment was laid out in a randomized block design comprising nine treatments of different dose of fertilizer with plant growth regulator namely chlormequat chloride and tebuconazole with three replications. Recommended dose of fertilizer i.e., 120:60:40 kg NPK ha⁻¹ was applied as per treatment. Available nitrogen, phosphorus and potassium content in soil after the harvest of wheat was significantly influenced by the application of different doses of fertilizer with significantly higher values recorded with the application of 150% recommended doses of NPK, while lowest available content of all the three major nutrients was recorded from control where no fertilizer was added. Growth regulators had no significant influence on the available nitrogen, phosphorus and potassium content in soil after the harvest of wheat. Significantly highest nitrogen content in both grain and straw was observed with the application of 150% recommended doses of NPK with growth regulators, while lowest value was recorded from control treatment. Significantly lowest phosphorus content in both grain and straw was recorded in control while all the other treatments receiving fertilizers with or without being at par with each other. Highest value recorded with application of 150% recommended doses of NPK. Growth regulators had no significant influenced on phosphorus content in both grain and straw. Potassium content in grain and straw was significantly influenced by fertilizer doses which showing highest is 150% recommended doses of NPK while lowest content was observed in control. Potassium content in both grain and straw was not significantly influenced by growth regulators. Uptake of all the major nutrients viz., nitrogen, phosphorus and potassium showed the similar trend with significantly highest uptake recorded with the application of 150% recommended doses of NPK with growth regulators while significantly lowest uptake of all the three nutrients was recorded in control. It concluded that nutrient management with growth regulator in wheat, economically viable and ecologically sound option to extend these benefits of balanced nutrition in enhancing both crop production and soil health.

Keywords: Wheat, Fertilizer, Plant growth Regulator, Chlormequat chloride, tebuconazole, Nutrient Balance sheet, Uptake of nutrient.

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1. INTRODUCTION

Wheat (*Triticum aestivum* L.) ranks as one of the world's foremost cereal crops, which can be grown in broad range of altitudes and latitudes. Renowned for its abundant reserves of carbohydrates and distinctive protein profile, fat and minerals (zinc, iron) and also contains good source of vitamins such as thiamine and vitamin-B wheat serves as a staple in both human and animal diets [1]. It stands as the primary dietary source for nearly 35% of the world population. On a global scale, wheat production spans 217.02 million hectares, yielding an impressive 765.4 million metric tons. In India, it is grown in 31.45 million hectare area with production of 107.592 million metric tons and productivity of 3.42 metric tonnes/ha [2]. In Madhya Pradesh, wheat is grown in 10.02 million hectares area with the production of 16.52 million metric tonnes and productivity of 3298 kg per hectares [3]. The estimated wheat production target for India by the year 2050 is approximately 140 million tonnes. This projection takes into account the increasing demand for consumption and trade driven by the growing population [4]. In order to produce more food, feed, and fiber from a smaller amount of land, nutrient application in agricultural systems will probably increase in the future years. However, achieving optimal wheat production while maintaining a nutrient-balanced ecosystem remains a formidable challenge. To sustainably enhance wheat crop yields and nutritional quality, it is imperative to optimize nutrient management practices while ensuring a balanced uptake of essential nutrients by the plants.

Nutrient balance in crop production is crucial for achieving optimal growth and yield. Imbalances in essential nutrients can lead to reduced crop productivity, increased susceptibility to diseases and pests, and compromised nutritional quality. Traditional approaches to nutrient management have often focused on the application of fertilizers to provide plants with the necessary elements for growth. However, **these** **this** practices have sometimes led to nutrient imbalances in the soil, affecting not only crop performance but also environmental sustainability. To address **this** challenges, contemporary agricultural research has explored innovative approaches aimed at optimizing fertilizer use while preserving nutrient balance. One such approach involves the integration of plant growth regulators (PGRs) with judiciously optimized fertilizer levels. Plant growth regulators are synthetic or naturally occurring compounds that influence the growth and development, including nutrient uptake, root development, and photosynthesis of plants in a targeted manner. By harnessing PGRs alongside precise fertilizer management, we have the potential to revolutionize wheat cultivation, achieving a dual objective of enhanced yield and improved nutrient balance.

This research paper explores "**Impact of optimizing fertilizer levels in combination with plant growth regulators on nutrient balance in wheat crops (*Triticum aestivum* L)**". It investigates the synergistic effects of these two interventions on nutrient uptake, utilization, and distribution within the wheat plants. The ultimate goal of this study is to contribute to sustainable and efficient wheat production practices that not only increase crop yields but also promote nutrient-balanced wheat, aligning with the broader objectives of global food security and nutrition.

2. MATERIAL AND METHODS

A field trial was carried out as part of the All India Coordinated Wheat Improvement Project during the rabi season of 2020–2021 at the research farm of the Jawaharlal Nehru Krishi Vishwa Vidyalaya in Jabalpur, Madhya Pradesh to evaluate the 'Impact of optimizing fertilizer levels in combination with plant growth regulators on nutrient balanced of wheat crops (*Triticum aestivum* L).The experiment was laid out in randomized block design with three replications, consisting nine treatments viz., T₁- 50% recommended doses of NPK, T₂- 75% recommended doses of NPK, T₃-100% recommended doses of NPK, T₄ - 125%

recommended doses of NPK, T₅ -150% recommended doses of NPK, T₆ -100% recommended doses of NPK with growth regulators spray(at first node stage and boot leaf stage (45 and 65 DAS respectively)), T₇ - 125% recommended doses of NPK with growth regulators spray (at first node stage and boot leaf stage), T₈ -150% recommended doses of NPK with growth regulators spray at first node stage and boot leaf stage), T₉ -Control (No fertilizer and growth regulators spray). The annual rainfall received during the growing season was 1350 mm in 2020-21. The soil of the experimental field was classified in clay loam in texture with a pH of 7.2, it contained a moderate amount of organic carbon (0.62%), low in available nitrogen (288.00 kg ha⁻¹), medium in available phosphorus (16.66 kg ha⁻¹) and available potassium (302.00 kg ha⁻¹). The concentration of soluble salts in the soil was below the harmful limit, measuring at (0.33ds m⁻¹). The field preparation included a deep ploughing using a mould board plough followed by two cross harrowing and planking. The Wheat variety MP 3382 was sown on November 16, 2020 and harvested on April 8, 2021 at the rate of 100kg ha⁻¹ with the spacing of 20 cm row- to- row. Recommended dose of fertilizer i.e N, P and K @ 120kg, 60kg and 60kg ha⁻¹ respectively. Half dose of nitrogen was supplied through Di-ammonium phosphate (DAP) and urea with full dose of phosphorus (P₂O₅) as DAP and potash (K₂O) as murate of potash were applied before sowing of seeds as basal application. The remaining half dose of nitrogen was applied in two equal splits as top-dressing during CRI (crown root initiation) and jointing stage. Following the specific treatment plan. The PGR used during experiment was chlormequat chloride available as Lihocin and tebuconazole available as Folicur. The Crop was grown under irrigated conditions, receiving a total of six irrigations at critical growth stages. Weeds control was managed through control two-hand weeding was done in all treatment plots with the help of weeding hookas needed. Gap filling was performed ten days after sowing to maintain the required plant population. The regular biometric observation were recorded at periodic intervals of 15 days after sowing (DAS), 30 DAS, 60 DAS, 90 DAS and at the harvest stage for selected plants. The observations were recorded on yield attributes and yield using standardized procedures [5]. The collected data were subjected to statistically analysis using the analysis of variance (ANOVA) technique, following the procedure suggested by Panse and Sukhatme [6]. Treatment comparisons are made at 5% levels of significance.

$$CD = S.E.d. \times t (0.05) (edf)$$

Where,

S. Em±} = standard error of treatment means

S. Ed±} = standard error of difference between treatment means

C.D = Critical difference

2.1 Soil Analysis

The soil samples were collected with the help of Khurpi (Spud) from each plot of the above-mentioned treatments representing the plough layer (0-15 cm) after harvest of wheat. Composite representative soil samples were obtained from these samples for each treatment. Each Composite sample consisted of a mixture of three sub samples from different site of each plot to secure representative sample of the plot selected for sampling. The mass of each collected sample was reduced to about 500 g by adopting the technique of quartering. These soil samples were air-dried, crushed by wooden pestle and mortar and were passed through 2 mm stainless steel sieve and stored in polythene bags at room temperature for analysis. **Soil pH** was determined in a 1:2.5 soil water suspension by glass electrode pH meter of Jackson [7]. **Electrical conductivity** of soil suspension used for pH determinations were allowed to settle down and conductivity of supernatant liquid was determined by using conductivity meter [7]. The results are expressed in dS/m at 25°C. **Organic Carbon** content was determined by Walkley and Black's rapid titration method [7]. **Available nitrogen (N) in soil** was determined by adapting the alkaline permanganate method of Subbiah and Asija [8]. **Available phosphorus** content of soil was estimated by extraction procedure as described by Olsen *et al.* [9]. The absorbance of blue color was read after 10

minutes, on spectrophotometer at 660 nm wavelength. **Available Potassium (K) in soil** was extracted with neutral normal ammonium acetate with flame photometer [7].

2.2. Plant analysis

The plant sample (*viz.*, wheat stover, grain,) were taken after harvesting from each plot for chemical analysis. Oven dried plant samples were grinded to fine powder in Willey mill with stainless steel blades. The powdered plant samples were used for nutrient analysis. The plant samples were subjected to wet digestion for estimating various nutrients in the stover, grain. For nutrients other than N, the plant sample was digested in a di-acid mixture *i.e.*, Mixture of HNO₃ and perchloric acid (9:4). This mixture was added for estimation of P and K. One-gram processed sample was taken in 50 ml flask and was placed in a low heat digestion chamber (160 °C). Then, heated at higher temperature (210 °C) until the production of red NO₂ fumes ceased. The contents were further evaporated until the volume was reduced to about 3 to 5 ml but not to dryness, indicating completion of digestion. After cooling flask, the solution was diluted with glass-distilled water and volume was made up to 100 ml volumetric flask. Aliquots of this solution were used for the determination of P and K. **Nutrient content (%)** Nutrient content of stover, grain *i.e.*, nitrogen, phosphorus and potassium were determined on dry weight basis at harvesting as per standard procedures. **Nitrogen (N)** Nitrogen concentration in prepared samples was determined by Modified Kjeldahl method as described by Prasad *et al.* [10]. **Phosphorus (P)** well ground seed and straw samples were digested in diacid mixture of HNO₃ and HClO₄ (4:1) and phosphorus concentration in the extract was determined by Vanado molybdate yellow colour method as described by Koeing and Johnson [11]. **Potassium (K)** Potassium concentraton in the diacid was determined by Flame-photometric method as described by Black [12].

Uptake of NPK by Straw

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{of NPK concentration in straw} \times \text{Straw yield (kg/ha)}}{100}$$

Uptake of NPK by grain

$$\text{Nutrient uptake (kg/ha)} = \frac{\% \text{ of NPK concentration in grain} \times \text{Grain yield (kg/ha)}}{100}$$

Total uptake

Total uptake of N, P and K was calculated for each treatment separately by using the following formula.

Total nitrogen uptake (kg ha⁻¹) = N uptake by grain + N uptake by straw

Uptake of N, P and K by wheat plants was expressed in kg ha⁻¹

2.3. Nutrient Balanced Sheet

Based on apparent gain or loss of nutrient, an attempt was made to establish fate of nutrient available in soil, added through different sources and crop removals in one season. The nutrient balance sheet was worked out as follows:

Expected nutrient balance (D) = (A+B) - C

Were,

A = Initial nutrient status of soil

B = Nutrient added as per treatment (Through fertilizer)

C = Nutrient taking by crop

Apparent gain /loss (F) = E -D

Were,

E = Actual nutrient balance i.e., the available nutrient status of soil after harvest of the crop

Actual gain / loss (G) = E – A

3. RESULTS AND DISCUSSION

3.1. Soil analysis

3.1.1. Available nitrogen

The data revealed the significant effect of fertilizer doses on the available nitrogen content of the soil after the harvest of wheat crop showed significantly highest available nitrogen content with the 150% recommended doses of NPK treatment followed by 150% recommended doses of NPK with growth regulators. Significantly lowest value of available nitrogen was recorded with the treatment in which no fertilizers was added. The differences in available nitrogen content in soil after the harvest of wheat were due to different quantities of nitrogen added to the soil.

3.1.2. Available phosphorus

The data revealed significant differences in available phosphorus content due to fertilizer doses with significantly higher value recorded when the crop was fertilized with 150% recommended doses of NPK followed by the application of 125% recommended doses of NPK with growth regulators and 150% recommended doses of NPK with growth regulators and control in that order, each treatment differing significantly from one another. The differences in available phosphorus content in soil were due to different quantities of phosphorus added to the soil.

3.1.3. Available potassium

The available potassium content in soil recorded after the harvest of wheat crop was significantly impacted by the fertilizer application. Significantly highest value was recorded with the application of 150% of recommended dose of NPK followed by 150% recommended doses of NPK with growth regulators and significantly lowest available potassium content was recorded in control treatment. The differences were due to the differences in the quantities of potassium added, its uptake in different treatments and its subject to various losses.

Thus growth regulators had no significant influence on the available nitrogen, phosphorus and potassium content in soil after the harvest. Similar finding recorded by Jat *et al.* [13] he reported significantly higher values of available NPK in soil when the wheat crop was fertilized with the higher dose of fertilizer (120:60:60) as compared to other doses.

Table 1. Available Nutrients in soil after harvest of wheat crop

Treatment	NITROGEN	PHOSPHORUS	POTASSIUM
50% recommended doses of NPK	280.750	14.760	289.450
75% recommended doses of NPK	283.630	15.010	291.880
100% recommended doses of NPK	289.860	17.410	304.560
125% recommended doses of NPK	291.580	18.110	307.950
150% recommended doses of NPK	297.320	18.970	311.630
100% recommended doses of NPK with growth regulators	289.770	17.560	304.350
125% recommended doses of NPK with growth regulators	290.580	18.560	307.300
150% recommended doses of NPK with growth regulators	296.420	18.220	311.360
Control (No fertilizer and growth regulators spray)	278.050	13.220	287.470
S.E.M ±	5.3468	0.3051	4.1355
C.D. @ 5%	16.0296	0.9148	12.3983

3.2. Plant studies

3.2.1. Nitrogen content

The data revealed that nitrogen content in both grain and straw was significantly influenced by the application of different doses of fertilizers and growth regulators. Significantly higher nitrogen content in grain with the application of 150% of recommended dose of NPK with growth regulators followed by application of 150% of recommended dose of NPK. Significantly lowest nitrogen content in grain and straw was recorded in control treatment where no fertilizers were added.

3.2.2. Phosphorus content

Data revealed the significant effect of fertilizer doses and growth regulators on phosphorus content in both grain and straw. Significantly higher phosphorus content in grain and straw was recorded with the application of 150% of recommended dose of NPK and significantly lowest phosphorus content in grain and straw was recorded in control treatment. This was due to the reason that soil in the control treatment was not able to provide the required quantities of phosphorus to the crop thus resulting in significantly lower phosphorus content.

3.2.3. Potassium content

The data revealed that potassium content in both grain and straw was significantly influenced by the application of different doses of fertilizers. Significantly highest potassium content in wheat grain and straw was recorded with the application of 150% recommended dose of NPK this treatment was followed by application of 125% recommended dose of NPK. Significantly lowest potassium content in grain and straw was recorded in control where no fertilizers were added.

Similar finding was reported by Rehman *et al.* [14], Kumar *et al.* [1], Pandey *et al.* [15], Mattas *et al.* [16], Shahi *et al.* [17], Paswan *et al.* [18] and Chesti *et al.* [19]. These results were a contradiction with Singh *et al.* [20] who reported that the increment in N uptake was probably due to improvement in soil conditions, which promoted the proliferation of roots and plant demand, which in turn drew more nutrients from larger area and greater depth. Under various spray treatments, maximum NPK uptake was recorded in 150% recommended doses of NPK with growth regulators. Effect of growth retardants on growth, biochemical, yield and yield components of wheat revealed that the application of Cycocel + Folicur in wheat crop recorded higher root growth due to maximum nutrient uptake, and protein content compared to control.

Table 2. Uptake of nutrient (on % basis) as influence by different treatment

Treatment	N Content		P Content		K Content	
	Grain	Straw	Grain	Straw	Grain	Straw
50% recommended doses of NPK	1.84	0.543	0.410	0.064	0.467	1.64
75% recommended doses of NPK	1.88	0.556	0.422	0.069	0.467	1.69
100% recommended doses of NPK	1.95	0.562	0.429	0.074	0.471	1.75
125% recommended doses of NPK	1.97	0.564	0.432	0.076	0.482	1.79
150% recommended doses of NPK	1.98	0.566	0.437	0.077	0.487	1.81
100% recommended doses of NPK with growth regulators	1.96	0.563	0.425	0.075	0.473	1.76
125% recommended doses of NPK with growth regulators	1.97	0.565	0.429	0.076	0.478	1.78
150% recommended doses of NPK with growth regulators	1.99	0.567	0.432	0.078	0.481	1.80
Control (No fertilizer and growth regulators spray)	1.82	0.525	0.399	0.059	0.47	1.61
S.E.M ±	0.03	0.0071	0.0063	0.0013	0.0009	0.026
C.D. @ 5%	0.10	0.0213	0.0191	0.0040	0.0026	0.077

3.3. Nutrient Balance Sheet

3.3.1. Apparent gain (+) or loss (-)

The result revealed that apparent gain (+) or loss (-) of NPK nutrient was recorded as control based treatment gave higher N positive value of apparent N and P with the value (63.03) and (6.03) respectively. Whereas, application of 150% recommended dose of NPK treatment gave more negative N and P apparent value (37.38) and (70.00) respectively. Application of 150% recommended dose of NPK gave higher positive value of K apparent (171.04). Whereas, 50% of recommended dose of NPK treatment gave minimum value of K apparent value (51.61).

3.3.2. Net gain (+) or loss (-)

The data showed that net gain (+) or loss (-) of NPK nutrient was recorded as control treatment gave more negative value of N and P loss value (9.95) and (3.44) respectively. Whereas, application of 150% recommended dose of NPK gave more positive N and P net gain value (9.32) and (2.31) respectively. Control treatment gave more negative value of K net gain (14.53). Whereas, 150 % recommended dose of NPK treatment gave maximum positive K net gain value (9.63) compare to other treatments.

Table 3. Nutrient balance sheet for Nitrogen as influence by different treatment

	Initial soil nutrient (A)	Nutrient added (B)	Nutrient uptake (C)	Expected balance in soil $D = (A+B) - C$	Actual soil fertility status (E)	Apparent gain (+) or loss (-) $F = E - D$	Net gain (+) or loss (-) $G = E - A$
50% recommended doses of NPK	288	60	83.65	264.35	280.75	16.40	-7.25
75% recommended doses of NPK	288	90	91.24	286.76	283.63	-3.13	-4.37
100% recommended doses of NPK	288	120	114.81	293.19	289.86	-3.33	1.86
125% recommended doses of NPK	288	150	124.60	313.40	291.58	-21.82	3.58
150% recommended doses of NPK	288	180	133.30	334.70	297.32	-37.38	9.32
100% recommended doses of NPK with growth regulators	288	120	139.40	268.60	289.77	21.17	1.77
125% recommended doses of NPK with growth regulators	288	150	143.81	294.19	290.58	-3.61	2.58
150% recommended doses of NPK with growth regulators	288	180	153.19	314.81	296.42	-18.39	8.42
Control (No fertilizer and growth regulators spray)	288	00	72.98	215.02	278.05	63.03	-9.95

Table4. Nutrient balance sheet for Phosphorus as influence by different treatment

Treatment	Initial soil nutrient (A)	Nutrient added (B)	Nutrient uptake (C)	Expected balance in soil $D = (A+B) - C$	Actual soil fertility status (E)	Apparent gain (+) or loss (-) $F = E - D$	Net gain (+) or loss (-) $G = E - A$
50% recommended doses of NPK	16.66	30	15.87	30.79	14.76	-16.03	-1.9
75% recommended doses of NPK	16.66	45	17.63	44.03	15.01	-29.02	-1.65
100% recommended doses of NPK	16.66	60	17.05	59.61	17.41	-42.20	0.75
125% recommended doses of NPK	16.66	75	16.22	75.44	18.11	-57.33	1.45
150% recommended doses of NPK	16.66	90	17.69	88.97	18.97	-70.00	2.31
100% recommended doses of NPK with growth regulators	16.66	60	18.24	58.42	17.56	-40.86	0.9
125% recommended doses of NPK with growth regulators	16.66	75	19.25	72.41	18.56	-53.85	1.9
150% recommended doses of NPK with growth regulators	16.66	90	20.93	85.73	18.22	-67.51	1.56
Control (No fertilizer and growth regulators spray)	16.66	00	9.47	7.19	13.22	6.03	-3.44

Table 5: Nutrient balance sheet for Potassium as influence by different treatment

Treatment	Initial soil nutrient (A)	Nutrient added (B)	Nutrient uptake (C)	Expected balance in soil $D = (A+B) - C$	Actual soil fertility status (E)	Apparent gain (+) or loss (-) $F = E - D$	Net gain (+) or loss (-) $G = E - A$
50% recommended doses of NPK	302	20	94.16	237.84	289.45	51.61	-12.55
75% recommended doses of NPK	302	30	102.07	239.93	291.88	51.95	-10.12
100% recommended doses of NPK	302	40	127.07	224.93	304.56	79.63	2.56
125% recommended doses of NPK	302	50	137.32	224.68	307.95	83.27	5.95
150% recommended doses of NPK	302	60	146.44	195.56	311.63	116.07	9.63
100% recommended doses of NPK with growth regulators	302	40	149.57	202.43	304.35	101.92	2.35
125% recommended doses of NPK with growth regulators	302	50	153.73	208.27	307.3	99.03	5.30
150% recommended doses of NPK with growth regulators	302	60	161.68	140.32	311.36	171.04	9.36
Control (No fertilizer and growth regulators spray)	302	00	83.00	219.00	287.47	68.47	-14.53

4. CONCLUSION

In the light of above study, it is concluded that availability of NPK in soil was independent of application of growth regulator while 150% recommended doses of NPK with growth regulators recorded maximum nutrient uptake by crop in grain and straw it shows an economically viable and ecologically sound option of nutrient management with growth regulator in wheat to extend these benefits of balanced nutrition in enhancing both crop production and soil health.

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