Original Research Article

Effect of Various Nitrogen Doses and Plant Growth Regulators on Nutrient Uptake and Productivity of Wheat(*Triticumaestivum*L)

ABSTRACT

field experimentwas conducted at Research Farm of BiharAgricultural University, Sabour, Bhagalpur, Bihar, during season of 2019-20, to find out the effect of otimization of nitrogen doses for high yield potential of wheat with plant growth regulators. The experiment was laid out in randomized block and replicated thrice. The experiment ten treatment of different doses of fertilizer with plant growth regulators chlormequat chloride and tebuconazole applied at 0.2% and 0.1% respectively. Experimental revealed that application of 150% recommended doses of NPK resulted significantly higheravailable nitrogen (171.82 kg ha^{-1}), available phosphorus (27.01 kg ha^{-1}) and available potassium (192.27 kg ha^{-1}) in soil after the harvest of wheat significantly highest nitrogen, phosphorus and potassium uptake by wheatrecorded with 150% RDF of NPK with chlormequat chloride (0.2%) and tebuconazole (0.1%). Significantly highest grain and straw yield recorded with 50%NPK + chlormequat chloride (0.2%) and tebuconazole (0.1%) at parwith100% RDFascompareto other treatmentsharvest index was recorded 125% RDF of N and chlormequat chloride (0.2%) and tebuconazole (0.1%) and150% RDF of N and chlormequat chloride (0.2%) and tebuconazole (0.1%). The uptake of key nutrients, nitrogen, phosphorus and potassium followed a similar pattern, with 150% recommended doses of NPK alongchlormequat chloride (0.2%) and tebuconazole (0.1%). optimal NPK application resulted in positive nutrient balance in the soil. This investigation that managing nutrient with growth regulator in wheat is an economically viable and ecologically sound approach to improve both crop production and soil health through balanced nutrition.

Keywords: Fertilizer, Nutrientlevels,nutrientuptake, PGR,wheat

1. INTRODUCTION

Wheatorginatedfrom SouthwestAsiaandbelongstothefamilyPoaceae. It's known for its abundant reserves of carbohydrates, distinctive protein profile, fat and minerals and also good soruce of vitamins such as thiamine ad vit-B. Wheat is referred as the "king of cereals" and is an important staple food crop for both human and animal, providing approximately half of the world's dietary caloies(USDA, 2020). Among the world's food crops wheat ranks first terms of production on an area of about 217.02million hectares and achieved 765.4 million metric tonnes(USDA, 2020).In India, wheat is cultivated on 31.45

million hectares of land, producing 112.74 million metric tons with a productivity of 3.42 metric tonnes/ha. (MoAFW., 2023). In Bihar wheat is grown on more than 2 million hectares of land and produce 5-6million tonnes. Wheat occupies 28% of the gross cropped area of Bihar and 70% of the sown area in the Rabi season (Kumbhar et al., 2023). The global call for wheat is estimated to reach around 840 MT worldwide by 2030 (Kumbhar et al., 2023)and projected wheat production target for India by the year 2050 is approximately 140 MT. This prediction accounts for the increasing demand for consumption and trade caused by the growing population. Nutrient application in agricultural systems is expected to rise in the next years in order to produce more food, feed, and fiber on a limited piece of land. However this is a challenge to achieve optimum wheat production by maintaining a nutrient balanced ecosystem. Proper nutrient management is a critical factor influencing the productivity wheat crop (Rajala et al., 2001). Balanced nutrient application in crop production is a important step to achieving optimal growth and yield. Improper management in essential nutrients leads to yield reduction, increases susceptibility of diseases pests and compromised nutritional quality. Conventional practices of nutrient management only emphasize on the application of fertilizers to provide plants with the necessary elements for growth. However these approaches have sometimes led to nutrient imbalances in the soil, affecting not only crop performance but also environmental sustainability. In order to address these challenges, modern agricultural research has explored innovative approaches aimed at optimized fertilizer use while conserving nutrient balance.One of the most effective approaches to involves integration of plant growth regulators with judiciously optimized fertilizer levels. Plant growth regulators have been recently reported to enhance growth and yield of wheat (Yang et al., 2006). 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 (Kumbhar et al., 2023). There are several phases during the growth cycle where PGRs could be applied for modification of plant growth and development. As a result, PGR's can be applied to modify plant growth and development at different phases of the growth cycle. Chlormequat, commonly known as ChlorCholineChloride (CCC), is a key agricultural growth regulator in many countries. It's an organic chloride salt and a quaternary ammonium salt. Chlormequat chloride is an organic salt that accomodates equal amounts of chlormequat and chloride ions. It has a role as a plant growth retardant and an agrochemical. After the use of Chlormequat chloride, it can effectively control plant growth, shorten the internodes of plants, make plant short, strong, thick, roots developed, resistant lodging, also darkening leaf color, thickening leaves, increased chlorophyll content, and increased photosynthesis, which increase the percentage of fruit set in certain crops, improve quality, and increase yield. By applying CCC at the beginning of stem elongation and the other PGRs at later stage, earlier to heading, cereal straw could be shortenedTebuconazole is a triazole fungicide and it is used in agriculture to intercept the plant pathogenic fungi. This fungicide is widely used to treat wheat seeds to prevent diseases caused by *Ustilago* spp., *Tilletia* spp. and *Fusarium* spp. It shows a systemic effect, consisting of penetration of the active substance through the protective tissues of plants. It is a standard in the control of fungal diseases from the genus *Fusarium*, especially those occurring in grain ears (Thabit et al., 2021). Moreover, tebuconazole is highly efficient against yellow and brown rust. Because of its long half-life, from 49 to 610 days, tebuconazole residues stay in the environment, including the atmosphere, soil, water, fruit and vegetables and cereals (Hrynko et al., 2023).Considering these points in view was conducted to determine the optimal fertilizer dosage levels in combination with growth regulators to achieve higher wheat yields. The is to contribute to sustainable and efficient wheat production practices that not only increase yield but also promote nutrient balanced wheat.

2. MATERIALSANDMETHODS

Experiment was carried out at research farm of Bihar Agricultural University, Sabour during the season of 2019-20 assess the effect of nitrogen doses for high yield potential of wheat. The experiment was laid out in randomized block design and replicated thrice. Recommended dose of fertilizer NPK 120:60:40kg/ha ($N:P_2O_5:K_2O$), [**T_1**-Control], [T_2-50% (RDF) recommended dose of nitrogen fertilizer:(i.e. 60kg N)], [**T_3**- 75% RDF of N:(i.e.90 kg N)], [**T_4**- 100% RDF of N:(i.e.120 kg N)], [**T_5**- 125% of N:(i.e. 150 kg N)], [**T_6**- 150%RDFofN:(i.e. 180kg)], [**T_7**-100%RDFofNPK:(i.e.120:60:40kg NPK)], [**T_8-** 125% RDF of N +Chlormequat chloride @ 0.2% + Tebuconazole @ 0.1% (i.e.150 kg N and 2ml + 1ml respectively)] at 45and 65 days after sowing (DAS), [**T_9-** 150% RDF of N +Chlormequat chloride @ 0.2% + Tebuconazole @ 0.1% (i.e.150 kg N and 2ml + 1ml respectively)] at 45 and 65 DAS and [**T_{10}**- 150% RDF of NPK +Chlormequat chloride @ 0.2% + Tebuconazole @ 0.1% (i.e.150 kg N and 2ml + 1ml respectively)] at 45 and 65 DAS. The experimentalhave sandyin texture, WheatcultivarDBW187wassownon second fortnight of Novemberatrowspacingof20cmapart100 kg/ha' Fertilizer was applied as per treatment of the experiment amount of Phosphorus and Potassium with1/3rd of nitrogen fertilizer was given as basal dose treatments. The remaining Nitrogen was applied in two splits, after first irrigation at crown root initiation (CRI) second irrigation at jointing stage respectively. The nutrient were supplied through inorganic sources viz. urea, DAP and MOP. Irrigation was given to crop as and when needed according to the crop requirement. Two irritations by which method irrigation was applied at a depth of 6 cm were given to the crop at critical stages when water availability is problem, first irrigation at CRI stage and second at flowering stage. First irrigation was applied at crown root initiation stage and second at jointing stage in wheat crop. Weed control was achieved through two manual weeding in all treatment plots using a weeding hook as needed first weeding was done at 30 day after sowing and second at 45 days after sowing of wheat. Gap filling was performed ten days after sowing to maintain the required plant population. Observations were recorded at intervals of 15 DAS, 30 DAS, 60 DAS, 90 DAS, and at the harvest stage.

2.1 Plant Nutrient Analysis Details

Plant sample (straw and grain) were taken at harvesting from each plot for nutrient estimation.Samples were oven-dried at 70^0C for 48 hours. The plant material thus obtained was grind with the help of a grinder and passed through 40 mesh sieves and preserved separately for determination of N, P, and K content. Totalnitrogen wasanalyzedbyKjeldahlmethod,phosphorus wasdeterminedthroughspectrophotometer and potassium was obtained by flamephotometer (Jackson et al., 1973). The nitrogen,phosphorus andpotassium contentingrainandstraw weremultiplied by the respective dry matter yield to estimate uptake (kgha^{-1}).

Nutrient uptake by Straw

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

Nutrient uptake by grain

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

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 and uptake of N, P and K by wheat plants was expresses in kg ha^{-1}.

2.2. Dry matter accumulations (q/ha)

2.3. Yield

2.3.1. Grain yield (q /ha)

The threshed grains of wheat obtained from each plot in all the treatments were sun dried and weighed separately as per the treatment and finally expressed as q/ha.

2.3.2. Straw yield (q/ha)

The straw yield was worked out by deducting the grain yield from the biological yield obtained from net plot of each treatment and converted to q/ha.

2.3.3. Biological yield (q/ha)

From each plot separately crop was harvested, bundled and weighed. Then the total biological yield was converted to q/ha.

2.3.4. Harvest Index (%)

The harvesting index is the ratio of economic yield to the biological yield and thus has been computed as economic yield (grain yield) divided by biological yield (Grain + Straw) and expressed in per cent.

The data recorded during the course of investigation were subjected to statistical analysis using analysis of variance (ANOVA) technique for randomized block design as prescribed by Gomez and Gomez, 1984. Standard error of mean in each case was calculated at 5% levels of probability

3. RESULTANDDISCUSSION

3.1. Growth Attributes

3.1.1. Dry matter accumulation (q/ha)

The effect of various treatments on accumulation of dry matter on wheat at different growth stages throughout the A perusal of data (fig-1) indicated that dry matter accumulation of wheat increased progressively from vegetative to maturity stage, at tillering stage, jointing stage viz. 30 and 60 days after sowing respectively significantly higher dry matter accumulation recordwith 150% RDF of NPK and growth regulator, which was closely followed 100% RDF of NPK also similar result was recorded at maturity stage. Dry matter production with increased application of nutrients was owing to the function of NPK in influencing and efficient use of sunlight via enhanced biological and insufficiency of nitrogen decreases the sunlight utilize efficiency or the facility to photosynthesise as already reported by Panchal et al., (2018).This might be due to adequate supply of nutrients allowed the plant tissue to grow large and increase the chlorophyll formation and stimulated rapid rate of photosynthetic activity, consequently recorded higher dry matter accumulation in comparison to its lower level (Ahmad et al., 2011). Jiang et al., (2019) reported that dry matter accumulation and translocation are closely related to the yield and N application significantly affects its accumulation and translocation (Demotes et al., 2004). Similar results observed byon winter wheat thatthe increase the dry matter accumulation in winter wheat increased gradually from the sowing stage to the jointing stage.

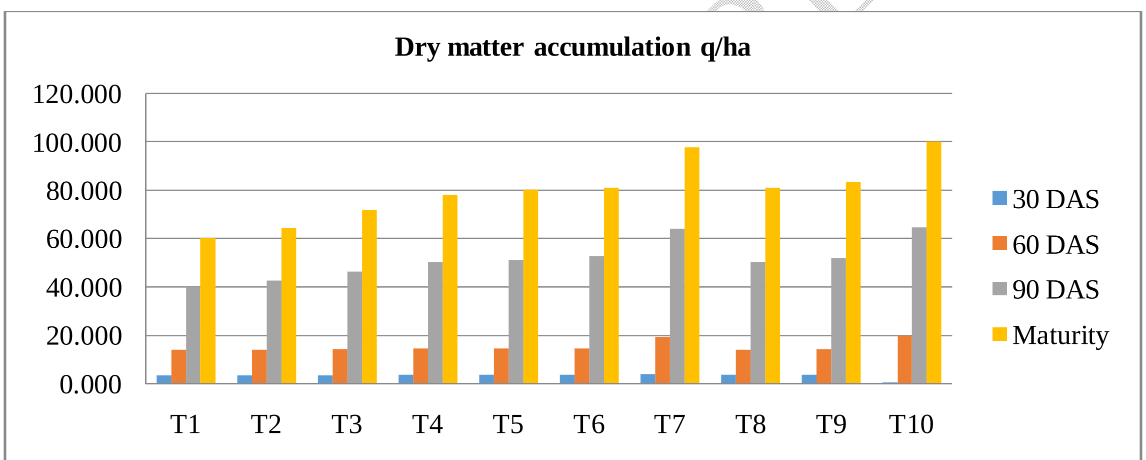

Fig-1-Effect of nitrogen doses and plant growth regulators on dry matter accumulation (q/ha) at different growth stages

(Growth regulators: Chlormequat chloride 0.2% and Tebuconazole 0.1%)

3.2. Yield (q ha^{-1})

Data presented in (table-1) revealed that grain yield, straw yield, biological index and harvesting index increased significantly with increasing nitrogen levels despite the application of growth regulators over control, significantly higher grain yield, straw yield and biological yield was recorded with 150% RDF of NPK along with Chlormequat chloride + Tebuconazole (51.71, 65.38 and 117.09 q/ha which was found statistically at par with 100 % RDF of NPK while harvest index 25% and 150% RDF of N with Chlormequat chloride + Tebuconazole were applied. This might be due to improvement in growth and yield attributing characters and higher photosynthetic activity. It is well-known fact that higher levels of fertilizer application enhance soil fertility and nutrient supply capacity. This increased fertility leads to improved nutrient uptake, plant growth and yield characteristics, ultimately grain and straw yields. These findings align with the research of

Table: 1. Effect of nitrogen doses and plant growth regulators on yield parameter of wheat.

Treatment		Yield (q ha^{-1})			HI (%)
		Grain	Straw	Biological	
T_1	Control	28.15	39.45	67.60	42
T_2	50% RDF of N	32.97	43.33	76.30	43
T_3	75% RDF of N	36.74	46.79	83.53	44
T_4	100% RDF of N	38.96	50.58	89.55	44
T_5	125% RDF of N	40.19	53.68	93.87	43
T_6	150% RDF of N	41.45	53.30	94.75	44
T_7	100% RDF of NPK	49.23	63.85	113.07	44
T_8	125% RDF of N with PGR (Chlormequat chloride 0.2% and Tebuconazole 0.1%)	43.06	52.02	95.08	45
T_9	150% RDF of N with PGR (Chlormequat chloride 0.2% and Tebuconazole 0.1%)	44.41	55.43	99.84	45
T_{10}	150% RDF of NPK with PGR (Chlormequat chloride 0.2% and Tebuconazole 0.1%)	51.71	65.38	117.09	44
SEm.(±)		1.29	1.48	2.45	0.01
CD (p=5%)		3.84	4.40	7.27	0.02

3.3. Nutrient Content

3.3.1. NPK content in grain and straw

The presented data revealed (Table-2) that the nitrogen content in both grain and straw of wheat was non-significantly influenced by the application of different doses of fertilizers and growth regulators. However, maximum nitrogen content was obtained in treatment T_1 (1.704 %) while minimum in treatment T_7 (1.644 %). Similarly Nitrogen content in straw was found maximum in treatment T_1 (0.745%) and minimum in treatment T_7 (0.673 %). Also the different levels of nitrogen fertilizer along with growth regulators did not influence the phosphorus content in grain as well as in straw of wheat, higher amount of phosphorus content in grain and straw was observed in Control and lowest (0.336%) in T_6. Also the similar trend of applied treatment was observed in potassium content of wheat grain and straw. K content in grain was recorded maximum in control (0.429%) whereas minimum content of potassium was recorded in treatment T_5 (0.354%). Similarly, potassium content in straw was recorded maximum in control (1.437%) and minimum in treatment T_5 (1.377%).

Thus, plant growth regulators had no discernible effect on the available nitrogen, phosphorus, and potassium concentration in soil after harvest. Although the similar pattern ofeffectofdifferent treatment doses ofnitrogenandgrowthregulatorsongrainandstrawwasobserved,where,significantly maximumNPKuptakewasattributedtocropresponseofgenerating highergrainyieldandbiomassin thetreatments which ultimately contributed to higher total uptakebywheatplant. Rahman et al., (2011)alsoreportedthe similarkindoffindings. Kishore et al., (2021) refuted these results, suggesting that the increased was likely due to improved soil conditions, which enhanced root growth and plant nutrient demand, allowing the plants to access nutrients from a larger area and greater depth. Among the various spray treatments, the highest NPK uptake was observed with 150% of the recommended NPK doses combined with growth regulators. The impact of growth retardants on wheat growth, biochemical composition, yield, and its components showed that applying Cycocel and Folicur resulted in better root growth, higher nutrient uptake, and increased protein content compared to the control.

Table:-2. Effects of Nitrogen doses and plant growth regulators on N, P and K content in grain and straw of wheat.

Treatment		**Nutrient content (%)**					
		Nitrogen		**Phosphorus**		**Potassium**	
		Grain	**Straw**	**Grain**	**Straw**	**Grain**	**Straw**
T_1	Control	1.704	0.745	0.356	0.155	0.429	1.437
T_2	50% RDF of N	1.694	0.721	0.354	0.154	0.415	1.430
T_3	75% RDF of N	1.688	0.711	0.351	0.151	0.401	1.411
T_4	100% RDF of N	1.666	0.709	0.344	0.146	0.389	1.406
T_5	125% RDF of N	1.665	0.695	0.336	0.139	0.354	1.377
T_6	150% RDF of N	1.658	0.692	0.334	0.136	0.355	1.381
T_7	100% RDF of NPK	1.644	0.673	0.352	0.151	0.410	1.413
T_8	125% RDF of N with PGR (Chlormequat chloride 0.2% and Tebuconazole 0.1%)	1.655	0.699	0.340	0.138	0.366	1.382
T_9	150% RDF of N with PGR (Chlormequat chloride 0.2% and Tebuconazole 0.1%)	1.654	0.706	0.337	0.136	0.361	1.385
T_{10}	150% RDF of NPK with PGR (Chlormequat chloride 0.2% and Tebuconazole 0.1%)	1.649	0.698	0.347	0.146	0.418	1.424
SEm (±)		0.01	0.01	0.01	0.005	0.02	0.02
CD (5%)		NS	NS	NS	NS	NS	NS

3.4. Nutrient Uptake

3.4.1. NPK uptake by grain and straw

Nutrient uptake by grain and straw of wheat revealed significant difference (fig-2a) among the different doses of nitrogen fertilizer and growth regulators. Higher uptake of nitrogen by grain as compared to straw with the application of 150% recommended doses of fertilizer NPK and growth regulator which was closely with 100% recommended doses ofNPK. Significantly higher uptake of nitrogen by grain, straw and total uptake was obtained with 150% RDF of NPK and growth regulator. Significantly lowest nitrogen uptake was recorded in treatment where fertilizer was not added. Phosphorus uptake (fig-2b) under the various level of nitrogen fertilizer and growth regulators revealed that phosphorus uptake by grain was maximum with 150% recommended dose of fertilizer NPK and growth regulator which was significantly higher than other treatments and significantly lower value was observed in control. Similar to the grain, in straw also maximum amount of phosphorus uptake was found with 150% RDF of NPK with growth regulator and total uptake also followed the similar trend of phosphorus uptake. While minimum amount of phosphorus was recorded in control treatment where no fertilizers were added. The data revealed (fig-2c) that potassium content in both grain and straw was significantly influenced by the application of different doses of fertilizers. Significantly the highest value of potassium uptake was gained by grain, straw and total with the treatment of 150% RDF of NPK with growth regulator followed by treatment with 100% RDF of NPK, while lowest value of potassium uptake was recorded in control.Treatments with increased nitrogen uptake were due to improved timing and distribution of nitrogen fertilizer applications throughout the season, which resulted in increased and uniform total nitrogen availability throughout the growing season, increased biomass, and increased accumulation of nitrogen, phosphorus, and potassium in the plants.Nutrients are involved in plant metabolism, so the amount of nutrient absorbed per unit volume of biomass production determines yield. The increase in phosphorus absorption was due to the significant increase in phosphorus that can be accessed on the soil. This is due to the highest accessibility of a higher dose, and deep penetration should contribute to the absorption of more nutrients in the root sphere. The absorption of potassium wheat has increased significantly compared to the maximum accessories of potassium for plant absorption. The low content and absorption of N, P, and K were observed under absolute control of insufficient supply and nutrients. Similar results were reported by Wuest et al., on wheat (1992), Khuranaet al., on wheat (2008) and Mohanty et al., (2016). also reported that nitrogen application increases soil N content and provides sufficient nutrients to the above ground part of the plant, thus promoting N uptake in winter wheat.

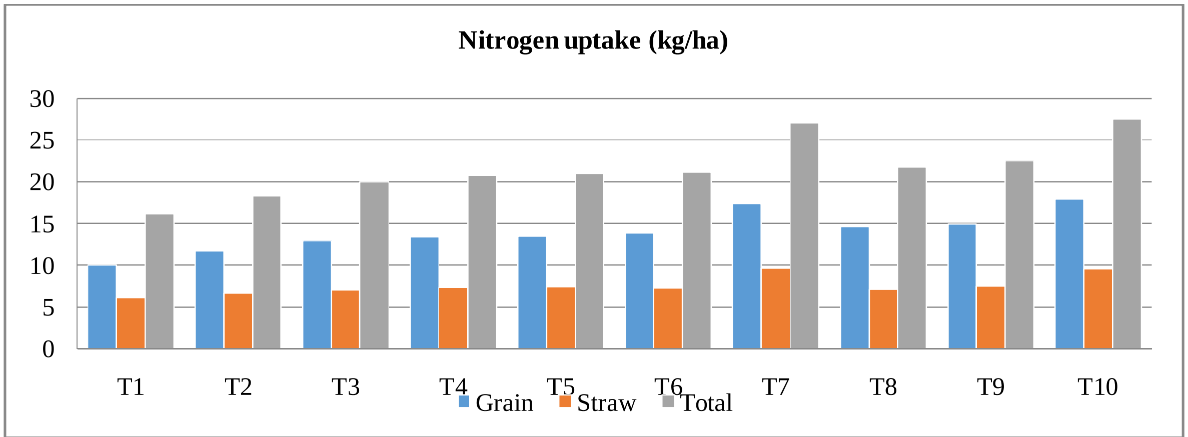

Fig-2a

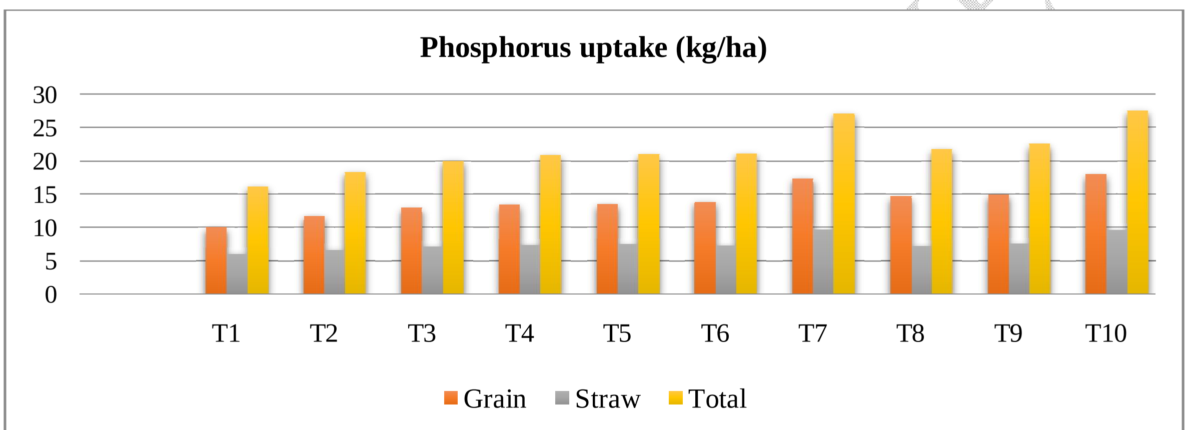

Fig-2b

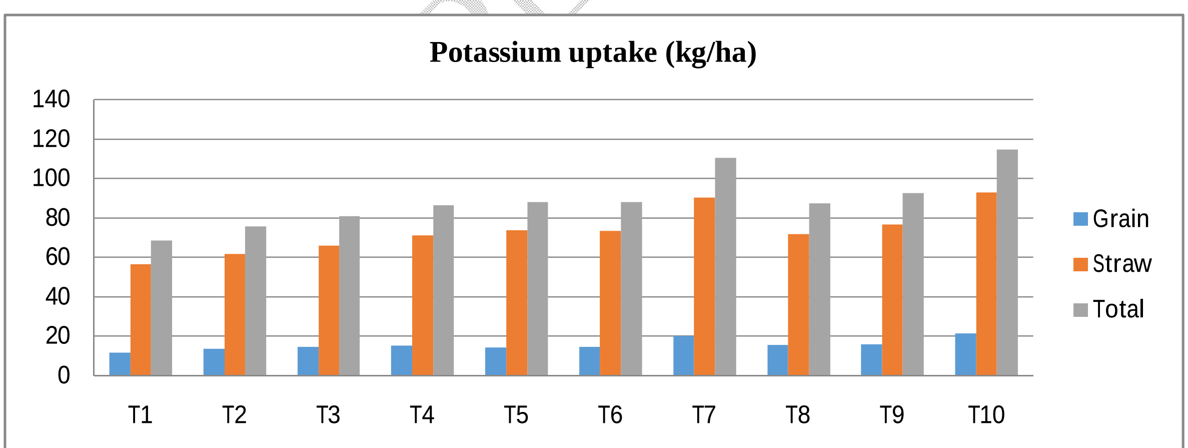

Fig -2C

Fig2(A-C):

Effect of nitrogen doses and plant growth regulators on NPK uptake (kg/ha) by grain and straw of wheat. (Growth regulators: Chlormequat chloride 0.2% and Tebuconazole 0.1%)

3.5. Soil Analysis

3.5.1. Available NPK content in soil

Data revealed (Table-3) that the significant effect of fertilizer doses on the available nitrogen, phosphorus and potassium content of the soil after the harvest of wheat crop. Significantly highest available nitrogen content with the 150% recommended doses of NPK treatment followed by 150% recommended doses of nitrogen fertilizer with growth regulator. Significantly the minimum value of available nitrogen was observed in the treatment in which no fertilizer was applied. The differences in available nitrogen content in soil after the harvest of wheat were due to different quantities of nitrogen applied in soil. The higher value of available phosphorus was also found in treatment with 150% recommended dose of NPK with growth regulator followed by 100% recommended dose of NPK and control in that order, each treatment differ significantly from one another. The variations in the available phosphorus content of soil were a result of the varying concentrations of phosphorus that were incorporated into the soil. The similar pattern of results was also recorded in available potassium content. Significantly highest value was recorded with the application of 150% recommended doses of NPK with growth regulator followed by 100% recommended doses of NPK while minimum value available potassium content was recorded in 150% of recommended doses of nitrogen. The differences were due to the difference quantities of potassium applied to soil, its uptake in different treatments and it subjected to losses. Thus it was concluded that no significant effect of growth regulators on available nitrogen, phosphorus and potassium content in soil after the harvest of wheat crop. Similar observations were recorded [21] their finding suggested that significantly higher value of available NPK in soil when the wheat crop was fertilized with the higher doses of fertilizer (120:60:60) as compared to other doses.

Table:3.Effect of nitrogen doses and plant growth regulators on the nutrient status of soil after the harvest of wheat.

Treatment		Available NPK content in soil (kg/ha)		
		Nitrogen	Phosphorus	Potassium
T_1	Control	138.81	22.43	175.41
T_2	50% RDF of N	145.20	22.36	175.00
T_3	75% RDF of N	150.01	23.29	177.22
T_4	100% RDF of N	156.52	22.11	176.44
T_5	125% RDF of N	162.67	22.24	177.02
T_6	150% RDF of N	167.16	23.50	174.04
T_7	100% RDF of NPK	157.38	25.87	187.17
T_8	125% RDF of N with PGR (Chlormequat chloride 0.2% and Tebuconazole 0.1%)	164.34	22.25	176.28
T_9	150% RDF of N with PGR (Chlormequat chloride 0.2% and Tebuconazole 0.1%)	169.16	22.38	175.22

T_{10}	150% RDF of NPK with PGR (Chlormequat chloride 0.2% and Tebuconazole 0.1%)	171.82	27.01	192.27
SEm(±)		3.7	0.53	1.73
CD (5%)		11.08	1.58	5.13

4. CONCLUSION

On the basis of summerized results it can be concluded that the Also contribute in more efficient nutrient use that maintain the soil fertility. This research helps in sustainable agriculture by maximizing yield potential and minimizing environmental impacts.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interest exist.

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