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ORIGINAL ARTICLE

Effect of Balanced Fertilization and Agro-Chemicals on Productivity of wheat (*Triticum aestivum*)

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ABSTRACT
The experiment was laid out in Split plot design having balanced fertilization in main plot and agrochemicals in sub plot with three replications. The soil of the experiment field was sandy loam in texture with alkaline in reaction and medium fertility status of soil DTPA extract. Results revealed that balanced fertilization treatments involving N, P, K, S, Zn and S+Zn nutrients, markedly improved parameters of growth, yield and quality as compared to N alone. Crop under the influence of conjoint application of NPKSZn recorded maximum plant height at harvest; dry matter accumulation at 30, 55, 80, 105 and at harvest stage; yield attributes viz., effective tillers m^{-1} ear length, grains ear^{-1} grain weight ear^{-1} and test weight; grain, straw and biological yields; chlorophyll content; uptake of nutrients as well as protein content in grain. Result showed that application of NPKS, NPKZn and NPKSZn significantly out yielded all the fertilization treatments and recorded additional 628, 397 and 814kg ha^{-1} grain and 899, 486 & 1202kg ha^{-1} straw yield as compared to NPK, respectively. While, compared to N alone application of NP, NPK, NPKS, NPKZn and NPKSZn bring increments of 326, 452, 1080, 849 and 1266kg ha^{-1} in grain yield, respectively. Maximum protein content in grain was estimated under NPKSZn followed by NPKS and NPKZn, which were significantly superior over rest of the treatments. Economic analysis revealed that NPKSZn treatments gave maximum net return which was significantly higher over rest of the treatments except NPKS. Maximum B: C ratio was obtained under NPKSZn treatment closely followed by NPKS which were significantly superior over rest of the fertilization treatments across the years. Foliar application of agrochemicals proved effective in improving growth and productivity parameters as well as protein content. As compared to control, all the bio-regulator exhibited significantly higher plant height, dry matter accumulation at various growth stages, yield attributes, yield parameters, harvest index, chlorophyll content, uptake of nutrients by crop and protein content. Among the agrochemicals, brassinolide application recorded maximum improvements in all these parameters followed by benzyladenine. Brassinolide proved significantly superior over thiourea and KCI with regards to dry matter accumulation at successive growth stages, effective tillers m^{-1}, grain ear^{-1}, test weight, grain yield, straw yield, chlorophyll content and nutrients uptake. Application of brassinolide 0.40ppm and benzyladenine 45 ppm produced additional grain yield of 864 and 809kg ha^{-1}, representing increment of 20.03 and 18.76%, respectively over control. Corresponding increments in straw yield were in the order of 20.21, 18.57 and 7.80%, respectively over control with foliar application of brassinolide, benzyladenine and thiourea. However, KCI remained at par with control in this regard. Economic evaluation reveals that application of brassinolide and benzyladenine provided additional net returns of Rs.-15586, 11881 ha^{-1}, respectively over control. In this regard, brassinosteroid proved significantly superior over thiourea, Maximum B/C ratio was fetched by brassinolide followed by benzyladenine, which proved significantly higher over control.
Keyword:-*NPK, CRI, KCL, DAS,*

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INTRODUCTION

Wheat is considered to be backbone of nation's food security system. Since green revolution in mid sixties, our country has witnessed significant increase in its productivity, thereby production which has transferred nation's status from scarcity to self sufficiency. Despite these significant achievements, there

is need for further enhancement in wheat production to feed ever burgeoning population and strengthening food security. Is has been estimated that India will need at least 109 million tons of wheat by 2020 as against present production of 73.3 million tons from of 25.5 million hectare [1]. Since very little scope exists for horizontal growth, the alternative seems to achieve growth through increasing productivity. Rajasthan shares near 10% of acreage and 9 per of total production of wheat in India. The productivity of wheat in Rajasthan state is around 35.94q/ha^{-1} with an area of 2.01 million hectare and production of 5.70 million tons [2-7]. There exists ample scope to improve the wheat productivity in the state at least up to feasible potential of 55-60 q ha^{-1} by systemic adoption of site-specific nutrient management practices with improved agronomic techniques. Wheat productivity level in India increased significantly up to the nineties. The average productivity increased to the extent of 46.5, 39.5 and 30.1%, respectively during the period 1960-70, 1970-80 and 1980-90. Thereafter, several factors led to a slowdown in this growth rate and negligible increase of only 6.7% could be achieved during 1990-2000 and productivity level has became stagnate at around 28q/ha^{-1} in present decade [9]. Major reasons for recently observed decline in growth rate of food grain production and factor productivity are large scale nutrient depletion through crop harvest on one hand and low level of nutrient replenishment to the soil on the other hand. Despite the application of recommended quantities of major nutrients, the increase in yield is not encouraging. This indicates that in addition to major nutrients, there is need to supply secondary and micro nutrients. Balanced nutrient of plains is one of most important factor determining ultimate crop productivity. However, continued cropping with only and NP containing fertilizers, that too at sub-optimal levels and neglected multi-nutrient deficiencies leading to imbalance among nutrients in soil and poor utilization of applied nutrients as well as other production inputs. Nutrient removal from the soil by crop must be restored by their application so as to maintain soil fertility. Therefore, balance use of fertilizers would be a major step for enhancing crop productivity[10-15]. At least five essential nutrients are of wide spread practical importance. In addition to key nutrients N and P, responses to k fertilization has been increasing with time and it has been considered as essential to include in fertilizer recommendation for optimization of crop yields in Rajasthan. Further, continuous use of S free fertilizer over the years has widen N: P: K: S ratio which has accentuated the deficiency of S in Indian soils. Sulphur is now considered as the fourth important plant nutrient in India and has becoming increasingly important for producing higher yields and better quality produce. Therefore, inclusion of sulphur for achieving balance in plant nutrition is of paramount importance in wheat. Moreover, sulphur deficiency adversely affects protein quality particularly with the high nitrogenous fertilizer application. Micronutrients have attained a great significance in today's intensive and exploitive agriculture aiming at increased crop productivity. Although the crops removes relatively small amount of micronutrients, often a few hundred grams per hectare when compared with several kilograms of macronutrients viz; N, P, K yet many soil are unable to provide sufficient amount of micronutrients for normal crop production. Deficiencies of macronutrients are increasing day by day under varying soil and crop situation. Zinc deficiency is the most wide spread among all the micronutrients and has been most widely reported in wheat. Most of the soils in Rajasthan have been reported to be deficient in available zinc. In recent years, Zn nutrition in wheat is considered to be integral part of balanced nutrient in many areas of the country. In major areas of Rajasthan, farmers generally apply only N or NP containing fertilizers, which have resulted in the depletion of S and Zn below the critical level in soil of many areas. Presently, addition of K, S and Zn are also considered as necessary part of balanced fertilization to achieving higher efficiency of applied nutrients and to enhanced productivity of wheat. Therefore, there is need to work out balanced fertilization recommendation involving combination of S and Zn with NPK for increasing productivity of wheat in Rajasthan. Among, agro-chemicals brassinokide is attributed due to its role in stimulating cell division/elongation by enhancing carbohydrate activity in stem and leaves. In many crops, brassinilide enhance the growth under varied environmental conditions. The effect of the application of benzyladenine indicated that it was antagonistic to moisture stress. At the concentration of 1-2x10^{-4} M it retarded senescence, thus increasing flower longevity. Thiourea is a sulphyldryl compound containing one SH group. The SH group has also been implicated in photosyntates translocation in crop plants. It is directly involved in light activation of photosynthetic enzymes. Thiourea 1000ppm foliar spray is reported to increase yield attributes, yield and quality parameters of various crops [10]. In plants potassium chloride also have been linked to various physiological processes. Potassium ion (K^+) plays significant role in plants, since it govern important role in osmoregulation. There aperas to be a good correlation between K^+ content of guard cells and stomatal aperture. Potassium has a general role in the regulation of water in plants cell. Under water stress condition potassium being absorbed selectively prevents the plants from losing water. Regulation of plant growth substances at the appropriate time and concentration has created a vast scope for further enhancing higher yields. Keeping in view the above

facts, a study entitled "Effect of balanced fertilization and agro-chemicals on productivity of wheat in south eastern Rajasthan" has been planned to conduct during Rabi season of 2014-15. (i) To work out balanced fertilization for wheat crop. (ii) To work out interaction effects, if any. (iii) To access the economics of treatments.

MATERIALS AND METHODS

The details of experimental treatments, materials used, procedures followed and criteria adopted for treatment evaluation during the course of investigation are presented in this chapter.

Climate and weather conditions:-The agro-climate zone-IIIa has semi-arid climatic conditions characterized by mild winters and moderate summers with higher relative humidity during the months of July to September. The average rainfall of the Zone-IIIa is 500mm, most of which is received between last week of June to September. Winter showers occur occasionally. A perusal of data shows that the maximum and minimum temperature during the wheat crop growing period ranged between 22.6 to 40.2^{o}C and 4.8 to 25.5^{o}C, respectively during the Rabi 2014-2015. Total rainfall of 39.2mm was received during the crop season.

Treatment application:-(i) Balanced fertilization:-Nitrogen, phosphorus, potassium, sulphur and zinc were applied at the rate of 120, 40, 30, 40 and 5.5 kg ha^{-1} through urea, DAP, muriate of potash, gypsum and zinc oxide, respectively. Zinc oxide was used instead of conventional zinc sulphate to ensure no 'S' reached to the soil through this source so that separate responses to S and Zn could be studied. The total quantity of phosphorus, potassium and half dose of nitrogen were drilled in furrows about 10 cm deep at sowing time as per randomly allotted treatments. The remaining half dose of nitrogen was top dressed in two splits, first at the time of first irrigation and another applied at the time of second irrigation. Full doses of gypsum and oxide were applied as basal before sowing. Soil was mixed with desired quantities to increase volume for ensuring uniform distribution within allotted plots as per treatments and thereafter spread and mixed thoroughly by rakes.

Bio-regulators:-The foliar sprays of each bio-regulator (brassinolide @ 0.5ppm, Benzyladenine (45ppm), KCL (1000ppm) and water spray in control) were made at two growth stages viz., first at maximum tillering (45-50DAS) and second at ear emergence (70-75DAS) as per treatment. A spray volume of 600 liters ha^{-1} was used during both the years of experimentation. In order to make sprays more effective, these were carried out either during morning or evening hours and teepol was mixed @ 0.5ml litre^{-1} with spray solution as a sticking agent. The required quantity of kinetin was first dissolved in 0.1 N NaoH and diluted with water to one litre and stored as stock solution for further use. Whereas readily available solution (0.1%) of brassinosteroid and LR grade thiourea were used directly to get final spray solution of desired concentration as per treatment.

Irrigation:-The crop was irrigated at five critical growth stages viz., crown root initiation (CRI), tillering, late jointing (boot), flowering and milk stage, during experimentation as per need of crop in experimental soil.

Weed management:-In order to reduce weed competition, 2,4-D @ 0.5kg ai ha^{-1} was applied 35 DAS as post-emergence spray through knapsack fitted with flat fan nozzle using 600 liters of water ha^{-1}.

Harvesting and threshing:-The plants from border area were harvested separately and removed from each plot. The plants of net plot area were harvested and produce was tied in bundles and sun dried. After proper drying, the bundles of each plot were weighed to record biological yield. The threshing was done with a power operated thresher.

Treatment Evaluation:-Plant stand m^{-1} row length:-The number of plants emerged were counted 20DAS in two randomly selected one meter row length of each plot and averaged to express as plant stand per meter row length.

Dry matter accumulation and it's partitioning:-The periodical dry matter accumulation at maximum tillering (45-50DAS), flowering (80-85DAS), milk (95-100DAS) and harvest stages were recorded by collecting whole plant samples from randomly selected two rows of 0.5m length in each plot at each aforesaid stage. Partitioning of each sample as stem, leaves and ears was done at flowering, milk and harvest stages and were put into perforated paper bags separately. These samples were dried in sunlight for 2-3 days and finally dried in an oven at 70^{o}C till contant weight was obtained.

Yield attributes:-Number of effective tillers m^{-1} row length:-At physiological maturity, numbers of effective tillers were counted non-destructively from two randomly selected one m row length in each plot. These were averaged to work out number of effective tillers m^{-1} row length in each experimental unit.

Ear length:-Random sampling of ten ears from each plot was carried out at physiological maturity and length of each ear was measured from base to the top to work out average ear length (cm) under each treatment.

Number of grains ear^{-1}:-The above mentioned randomly selected ten ears from each plot were threshed and grains were counted for determining the average number of grains ear^{-1}.

Grain weight ear^{-1}:-The grains form randomly selected ten ears were weighted and averaged to workout grain weight ear^{-1} (g).

Test weight (g):-The grain samples were drawn from the produce of each plot while weighing the net plot yield. Thousand grains were counted from each of selected grain samples and weighed on an electric top pan balance to workout test weight (g).

Yield and Harvest index:-Biological yield:-The above ground portion of plants of net plot area after harvest were sun dried for about one week and then weighed to work out biological yield expressed in terms of q ha^{-1}

Grain yield:-After threshing and winnowing, grain yield from each plot was weighed separately and recorded as kg per plot. Thereafter, it was expressed in terms of q ha^{-1}**.**

Straw yield:-The straw yield (q ha^{-1}) for each treatment was obtained by subtracting the corresponding grain yield from the biological yield.

Harvest index (%):-The harvest index was computed by using the following formula (Donald and Hamblin, 1976).

$$\text{H.I. (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} * 100$$

Bio-chemical studies:-Chlorophyll content of leaves:-Total chlorophyll content of fresh leaf samples (80DAS) were estimated by the method suggested by Arnon (1949). The total chlorophyll content was estimated by the following formula:-

$$\text{Total chlorophyll content (mg g} - \mathbf{1}\text{ fresh weight)} = \frac{20.2(A645) + 8.02(A663)}{a \times 1000 \times w} * V$$

Where:-a= length of light path in cell (1cm), V= Volume of extract, W= weight of leaf sample

Nutrient Content in grain and straw:-The grain and straw samples from the produce of each plot were collected and oven dried at 70^{o}C to obtain constant weight. The samples were ground to pass through 40 mesh sieve. These samples were analyzed for N, P, K, S and Zn content in grain and straw by using following standard methods of analysis. (i) Nitrogen:-Nesselers reagent colorimetric method. (ii) Phosphorus:-Vanado-molybdo-phosphoric acid yellow colour method. (iii) Potassium:-Flame photometric method. (iv) Sulphur:-Turbidemetric method. (v) Zinc:-Atomic absorption spectrophotometer method.

Nutrient uptake in grain, straw and total by crop:-The N, P, K, S and Zn uptake by grain and straw at harvest were computed by multiplying respective grain and straw yields (q) with per cent nutrient content and expressed as kg ha^{-1}. Total uptake of each nutrient by the crop was derived by summing uptake in grain and straw.

Protein content in grain:-The protein content in grains was estimated by multiplying per cent content in the grain with the factor 6.25 and expressed as percent protein content.

Economic evaluation:-To find out the economic feasibility of different treatments, treatment-wise cost of cultivation and net returns were calculated. Benefit to cost (B/C) ratio was then worked out for different treatments as follows:-Net returns (Rs ha^{-1}) = Gross return ha^{-1}- Cost of cultivation ha^{-1}

$$\frac{B}{C} \text{ ratio} = \frac{\text{Net returns}}{\text{Cost of cultivation}}$$

RESULTS AND DISCUSSIONS

Results of the field experiment entitled, "Effect of Balanced Fertilization and Agro-chemicals on Productivity of Wheat (Triticum aestivum L.)" conducted during Rabi season of 2014-15 are presented in this chapter. Since the interaction effects of the balanced fertilization and agro-chemicals treatments were not found to be statistically significant, only the main effects of the treatments are presented, the data have been averaged over agro-chemicals treatments for balanced fertilization treatments or over balanced fertilization treatments or over balanced fertilization treatments for agro-chemicals treatments.

Effect of Balanced Fertilization and Agro-Chemicals on Plant Stand:-A perusal of data reveals that different fertilization treatments did not significantly influence the plant stand m^{-1} row length recorded

after full germination. As agro-chemicals were sprayed later, the values shown against agro-chemicals treatments are for reference study, which also did not vary significantly.

Effect of Balanced Fertilization and Agro-Chemicals on Growth Ammeters:-Balanced fertilization:- Data presented in Table 4.1 reveal that plant height was significantly increased due to balanced fertilization treatments over N alone. Maximum plant height was observed with conjoint application of NPKSZn followed by NPKS and NPKZn, which were significantly superior over N, NP and NPK. While NPKS remained at with NPKSZn and NPKZn. Application of NPKS, NPKZn and NPKSZn increased plant height by 10.27, 6.97 and 12.98%, respectively as compared to NPK.

Agrochemicals: An examination of data presented in Table 4.1 reveals that foliar application of agrochemicals had significant effect on plant height at harvest. Application of Brassinolide and Benzyladenine recorded 9.90, 16.83 & 24.00 and 6.10, 12.70 and 19.61% higher plant height at harvest over thiourea, KCI and control.

Dry matter accumulation:-Dry matter accumulation at 30DAS:-Balanced fertilization:-A perusal of data revealed that balanced fertilization treatments significantly improve DMA m^{-1} row length at 30DAS of the crop over N alone. Crop accumulated maximum dry matter under the fertilization of NPKSZn fertilization, which was statistically superior over rest of the fertilization treatments. NPKS and NPKSZn recorded 9.10 and 11.69% higher dry matter accumulation at 30 DAS over NPK, respectively.

Agrochemical:-Data presented in Table 4.2 reveals that dry matter accumulation of wheat crop at 30DAS was failed to show a significance level under application of agrochemicals.

Dry matter accumulation at 55DAS:-Balanced fertilization:-A critical examination of the data presented in Table 4.2 show that balanced fertilization treatments significantly improved DMA at 60 DAS over N alone. The magnitude of increase was 7.72 and 10.25% with application of NPKS and NPKSZn over NPK.

Agrochemicals:-Data revealed that foliar application of brassinolide recorded maximum dry matter accumulation at 60DAS, which was found remain at par with Benzyladenine and significantly superior over thiourea, KCI and water spray control. The Magnitude of corresponding increases over 8.06, 10.84, and 12.68% higher over thiourea, KCI and control, respectively.

Dry matter accumulation at 80 DAS:-Balanced Fertilization:-Application of NPKSZn recorded maximum dry matter accumulation at 80DAS over rest of the treatments and registering 8.37, 10.55, 22.08, 16.47 and 27.49 % respectively higher over N, NP, NPK, NPKS, and NPKSZn respectively.

Agrochemicals:-A critical examination of data presented in Table 4.2 shows that foliar application of brassinolide at 040ppm significantly recorded maximum dry matter accumulation over thiourea, KCI and control and closely followed by benzyladenine. Application of brassinolide recorded 10.52, 11.61 and 13.02% higher maximum dry matter accumulation at 80DAS over thiourea, KCI and control spray respectively.

Dry matter accumulation at 105 DAS:-Balanced fertilization:-Data presented in Table 4.2 reveals that application of N, NP, NPK, NPKS, NPKSZn recoeded significantly higher DMA at 105 DAS over N alone. The magnitude increase over in the order of 7.10, 7.92, 16.85, 12.28 and 24.12% respectively.

Agrochemicals:-An examination of data Table 4.2 clearly reveals that foliar application of brassinolide and benzyladenine was found remain at par with each other in dry matter accumulation at 105 Das and both were significantly improved dry matter accumulation over thioures, KCI and water spray by a margin of 9.87, 13.05, 14.03, 6.34, 9.42 and 10.36% respectively.

Dry matter accumulation at harvest:-Balanced fertilization:-An examination of data presented in Table 4.2 reveals that balanced fertilization had significant improvement in dry matter accumulation at harvest stage. Application of NPKSZn recorded significantly maximum dry matter accumulation at harvest, which was found at par with NPKS and both were significantly improved dry matter accumulation over NPK and registering 6.64 and 11.31%. Data further revealed that NPKSZn recorded significantly dry matter accumulation at harvest over NPKZn by registering 8.36%.

Agrochemicals:-A critical examination of data presented in Table 4.2 clearly reveals that foliar application of brassinolide recorded significantly higher dry matter accumulation at harvest over thiourea, KCI and water spray, and was found remain at with enzyladenine. Application of brassinolide recorded 5.92, 9.25 and 10.49% higher dry matter accumulation at harvest over thiourea KCI and water spray. The magnitude of increase was 6.38 and 7.59% over KCL and water spray.

Effect of Balanced Fertilization and Agro-Chemicals on Yield Attributes:-Effective tillers m^{-1} row:-Balanced fertilization: It is evident from the data that additional application of P, S, Zn and S + Zn significantly increased number of effective tillers m^{-1} row. Application of NPKS, NPKZn and NPKSZn increased number of effective tillers by 8.57, 5.60 and 11.07% respectively over NPK. Whereas, increment due to NP fertilization was 7.33% as computed to N alone.

Agrochemicals:-Data presented in Table 4.3 reveals that foliar application of brassinolide and benzyladenine was found statistically at par to each other and both were recorded significantly higher effective tillers m^{-1} row length over thiourea, KCL and water spray. The magnitude of percent increase was to the tune of 6.46, 12.16, 14.41, 5.55, 11.21 and 13.43 respectively over thiourea, KCL and water spray.

Ear length:-Balanced fertilization:- NPKS fertilization also increased ear length significantly over NPK. NPKSZn, NPKS and NPKZn fertilization improved ear length to the extent of 5.61, 5.33 and 4.94% over NPK. Whereas NP fertilization increased it by 0.55cm over N alone. Further, addition of K did not significantly improve ear length over NP.

Agrochemicals:-An examination of data presented in Table 4.3 reveal and that foliar application of brassinolide recorded maximum ear length which was statistically found at par with benzyladenine and higher over thiourea, KCI and water spray. The percent increase was 7.54, 13.72 and 16.70. Data further revealed that foliar application of thiourea also recorded 5.74 and 8.59% higher ear length over KCI and water spray.

Grains ear^{-1}:-Balanced fertilization:- Data indicate that application of NPKS, NPKZn and NPKSZn treatments increased grains ear^{-1} by 8.08, 6.49 and 8.35%, respectively over NPK alone. Application of NP and NPK increased grains ear^{-1} in the order of 10.53 and 15.47%, over N alone and NP, respectively.

Agrochemicals:-Data presented in Table 4.3 revealed that foliar application of brassinolide recorded significantly maximum number of grains ear^{-1} over rest of the agrochemicals test except benzyladenine and registering 7.85, 14.05 and 15.03% over thiourea, KCL and water spray.

Grain weight ear^{-1}:-Balanced fertilization:-A perusal of data revealed that additional fertilization of PKS, Zn and S+Zn significantly improved grain weight ear^{-1}. The magnitude of increases was 0.35, 0.52, 0.74, 0.687 and 0.76g ear^{-1} over N alone.

Agrochemicals:-An examination of data presented in Table 4.3 reveals that foliar application of agrochemicals had significant effect on grain weight ear^{-1}, Application of brassinolide and benzyladenine recorded 31.21 and 27.75% higher grain weight ear^{-1} over water spray.

Test weight:-Balanced fertilization:- NPKS, NPKZn and NPKSZn improved test weight by the magnitude of 9.56, 4.85%, respectively over NPK. While, NP fertilization increased test weight by the margin of 5.62% in comparison to N alone.

Agrochemicals:-Data presented in Table 4.3 reveals that foliar application of brassinolide recorded significantly higher test weight over thiourea, KCI and water spray and remained at par with benzyladenine. The magnitude of increase was 7.98, 13.47, 16.78 and 7.03, 12.47 and 15.76% higher over thiourea, KCI and control with application of brassinolide and benzyladenine, respectively. Data further revealed that foliar application of thiourea also recorded significantly higher test weight over KCI and water spray and registering 5.08 and 8.15% respectively.

Effect of Balanced Fertilization and Agro-Chemicals on Yield and Harvest Index:-

Grain yield:-Balanced fertilization:-A perusal of data reveals that additional fertilization of P, S, Zn and S+Zn significantly increased grain yield. Application of NPKS, NPKZn and NPKSZn increased grain yield over NPK to the extent of 13.90, 8.78 and 18.01%, respectively. While, NP fertilization bring increment of 8.02% over N alone. NPKSZn fertilization produced additional grain yield of 8.48% over NPKZn. Additional increments of 10.80 and 8.49q ha^{-1} were observed due to NPS and NPKZn fertilization, respectively over N alone.

Agrochemicals:-An examination of data clearly indicate that foliar application of brassinolide recorded significantly maximum grain yield over thiourea, KCI and water spray except foliar application of benzyladenine. The corresponding increases were to the tune of 14.18 & 12.97%, 15.07 & 13.85 and 20.03 & 18.76% higher over thiourea, KCI and water spray with application of brassinolide and benzyladenine, respectively.

Straw yield:-Balanced fertilization:-Increments in straw yield due to application of NPKS and NPKZn and NPKSZn were in the magnitude of 13.04, 7.05 and 17.43%, respectively over NPK. While increment due to NP fertilization over N alone was by 20.71%. NPKSZn fertilization recorded additional straw yield of 1202, 303 and 716kg ha^{-1} over NPK, NPKS and NPKZn, respectively. Additional straw yield due to NPKS and NPKZn fertilization over NPK were in the order of 899 and 486kgha^{-1}, respectively. Whereas, in comparison to N alone, NP fertilization resulted in an additional straw yield of 1126kg ha^{-1}.

Agrochemicals:-A critical review of data revealed that foliar application of brassinolide recorded 12.26, 16.27 and 20.21% higher straw yield over thiourea, KCI and control. Foliar application of benzyladenine also recorded 10.73, 14.68 and 18.57% significantly higher as compared to thiourea, KCI and water spray. Data further revealed that foliar application of thiourea also significantly received higher straw yield over control by a margin of 7.08%.

Harvest index:-Data presented in Table 4.4 indicate that different balanced fertilization and foliar application of agrochemical treatments did not bring significant variation in harvest index. Harvest index varied between 39.59 to 42.73% under different fertilization treatments.

Biochemical Parameters:-Effect of Balanced Fertilization and Agro-Chemicals on Total Chlorophyll Content:-

Balanced fertilization:- Application of NPKSZn, NPKS and NPKZn increased total chlorophyll content to the extent of 6.85, 6.10 and 6.25%, respectively over NPK fertilization, while application of NP significantly enhanced it by 1.71, 6.52, and 2.54% over N alone.

Agrochemicals:-A perusal of the data presented in Table 4.5 reveals that brassinolide and benzyladenine foliar sprays reported maximum in chlorophyll a chlorophyll b and total chlorophyll content over thiourea, KCI and water spray. However both of these agrochemicals remained at par to each other. Foliar application of brassinolide and benzyladenine recorded 3.36, 5.23, 7.88, 1.63, 3.47 and 6.08% higher over thiourea, KCI and water spray.

Effect of Balanced Fertilization and Agro-Chemicals on Nutrient Content in Grain and Straw:-

Nitrogen content:-Grain:-Balanced fertilization:-Data presented in Table 4.6 reveal that balanced fertilization treatments significantly influenced the nitrogen content in grain. NPK fertilization significantly enhanced over NP. NPKS, NPKZn and NKPSZn increased N content in grain by 0.067, 0.045 and 0.083 units, respectively as compared to NPK. Whereas, NP fertilization increased it by 4.75% over N alone.

Agrochemicals:-Data presented in Table 4.6 reveals that foliar application of brassinolide recorded significantly maximum N content in seed over thiourea, KCI and water spray except benzyladenine. Application of brassinolide recorded 6.06, 8.94 and 9.94% significantly higher over thiourea, KCI and water spray.

Straw:-Balanced fertilization:- As compared NPK, N content in straw was increased to the extent of 12.18, 10.31 and 13.75%, respectively due to NPS, NPKZn and NPKSZn fertilization. While, NP fertilization increased it by 0.009 units over N alone.

Agrochemicals:-A perusal of the data presented in Table 4.6 reveals that application of brassinolide, benzyladenine and thiourea recorded 16.55, 13.96, 6.82 and 17.70, 15.08 and 7.87% higher N concentration in straw over KCI and water spray.

Phosphorus content:-Grain:-Balanced fertilization:-An examination of data presented in Table 4.6 reveal that P content in grain was significantly increased over N alone, due to all the balanced fertilization treatments.

Agrochemicals:-Data presented in Table 4.6 revealed that foliar application of brassinolide remained at par with benzyladnine and both these were recorded significantly higher P content in seed over thiourea, KCI and water spray. The magnitude of increase was 4.20, 6.53, 7.05, 3.55, 5.87 and 6.38% higher.

Straw:-Balanced fertilization:- Application of NPKSZn fertilization increased P content of straw by 20.38 and 9.38%, respectively over N alone.

Agrochemicals:-An examination of data shows that foliar application of brassinolide, benzyladenine and thiourea recorded significantly higher N content in straw over KCI and water control. The percent increases were 7.89 & 8.97, 6.66 & 7.72 and 3.08 & 4.11% higher over KCI and water spray.

Potassium content:-Grain:-Balanced fertilization:-It evident from Table 4.6 that K content in grain was significantly increased due to balanced fertilization treatments over N alone. Application of NP, NPK, NKZn and NPKSZn increased K content of grain to the magnitude of 4.18, 7.86, 10.57, 10.07 and 12.04%, respectively over N alone.

Agrochemicals:-Application of brassinolide recorded 4.60, 6.56, 7.31% higher and benzyladenine recorded 2.76, 4.68 and 5.42% higher K content seed over thiourea, KCI and water spray.

Straw:-Balanced fertilization:- Application of NPK significantly increased K content in straw as compared to NP alone. Application of NP, NPK, NPKS, NPKZn and NPKSZn increased K content in straw by the margin of 5.78, 8.49, 11.25, 11.18 and 11.45%, respectively over N alone.

Agrochemicals:-A critical examination of data presented in Table 4.6 reveals that foliar application of brassinolide and benzyladenine was found statistically at par to each other and both were significantly higher K content in straw over thiourea, KCI and water spray. The magnitude of percent increases 8.75, 11.67, 12.66, 7.96, 10.86 and 11.84 higher over thiourea, KCI and water spray.

Sulphur content:-Grain:- Balanced fertilization:-A reference to data presented in Table 4.7 reveal that S content in grain was significantly increased due to balanced fertilization treatments over N alone. N, NP, NPK, NPKS and NPKSZn increased S content in grain to extent of 5.43, 6.10, 7.21, 6.10 and 9.1%, respectively as compared to N.

Agrochemicals:-Brassinolide and benzyladenine is S content in grain to the extent of 0.021, 0.023, 0.013 and 0.015 units as compared to KCI and water spray.

Straw:-Balanced fertilization: As evident from data S content in straw was significantly enhanced over N alone due to balanced fertilization treatments. While application of NPKZn did not bring significant increment as compared to NPK and NPKS. Application of NP, NPK, NPKS, NPKZn and NPKSZn recorded 12.62, 12.62, 18.45, 15.05 and 21.36% higher as concentration in straw over N alone.

Agrochemicals: A perusal of data presented in Table 4.7 reveals that foliar application of brassinolide and benzyladenine resulted in significantly higher S content in straw over KCI and water spray; however, both these treatments remained at par to each other. Brassinolide and benzyladenine recorded 3.77, 4.82 and 3.04 and 3.95% higher S content in straw over KCI and water spray.

Zinc content:-Grain:-Balanced fertilization:-A perusal of data presented in Table 4.7 reveals that application of NPKZn and NPKSZn recorded significantly higher Zn content in grain over rest of the fertilization treatments. Zn content in grain increased due to application of NPKSZn to extent of 8.51, 5.09, 3.74, 1.49 and 0.89ppm, respectively over N, NP, NPK and NPKS. Corresponding increment due to NPKZn were in the order of 24.69, 12.25, 8.00 and 1.58%, respectively.

Agrochemicals:-An examination of data presented in Table 4.7 shows that foliar application of brassinolide recorded significantly higher in Zn content in seed/grain over benzyladenine, thiourea, KCI and water spray. The magnitude of increase was 2.25, 3.44, 6.73 and 7.89%, respectively. Data further revealed that foliar application of benzyladenine was remained at par with thiourea and significantly higher over KCI and water spray and registering 4.38 and 5.52%, respectively.

Straw:-Balanced fertilization:-Data indicate that NPKZn and NPKSZn fertilization recorded significantly higher Zn content in straw over rest of the treatment except NPKS. However, both these treatments remained at par with each other. Application of NP, NPK, NPKS, NPKZn and NPKSZn recorded 0.81, 1.60, 2.11, 2.44 and 2.63ppm higher Zn content in straw, respectively.

Agrochemicals:-A perusal of data presented in Table 4.7 revealed that foliar application of brassinolide recorded significantly higher Zn content in straw over thiourea, KCI and water spray, however, it was remained at par with benzyladenine and both were registering 8.01 and 8.97% higher Zn content in straw over water spray.

Effect of Balanced Fertilization and Agro-Chemicals on Nutrient uptake:-Nitrogen uptake:-

Grain:-Balanced fertilization:-Application of NPKS and NPKZn and NPSZn increased N uptake in grain to the extent of 18.60, 11.80 and 24.13%, respectively over NPK. While NP fertilization increased it by 12.69% as compared to N alone. The magnitude of increases was to the tune of 12.69, 19.82, 42.11, 33.96 and 48.72%, respectively.

Agrochemicals:-Data revealed that foliar application of brassinolide recorded significantly higher nitrogen uptake over rest of the agrochemicals tested, however, it was found remain at par with benzyladenine. The corresponding increases were in the order of 21.46, 25.43, 32.312, 17.56, 21.41 and 28.08%, respectively higher over thiourea, KCI and water spray. Data further revealed that foliar application of thiourea also recorded 8.94% significantly higher N uptake by grain over water spray.

Straw:-Balanced fertilization:-Data reveal that N uptake in straw was significantly enhanced due to balanced fertilization treatments over N alone. Application of NPKS, NPKZn and NPKSZn increased N uptake in straw by 26.98, 18.30 and 33.57%, respectively over NPK. While NP fertilization increase it by 23.40% as compared to N alone.

Agrochemicals:- Data revealed that foliar application of brassinolide recorded significantly higher nitrogen uptake over rest of the agrochemicals tested, however, it was found remain at par with benzyladenine. The magnitude of corresponding increases was in the order of 22.04, 34.12, 41.64, 17.92, 29.58 and 36.58%, respectively higher over thiourea, KCI and water spray.

Total N uptake:-Balanced fertilization:-Application of NPKS, NPKZN and NPKSZn enhanced totoal N uptake by the magnitude of 20.47, 13.25 and 26.22%, respectively as compared to NPK. Whereas, NP fertilization bring 14.80% increment in it as compared to N alone and NPK fertilization bring 23.78% increased it as compared to N alone.

Agrochemicals:-Data revealed that foliar application of brassinolide recorded significantly higher total nitrogen uptake over rest of the agrochemicals tested, however, it was found remain at par with benzyladenine. The corresponding increases were in the order of 21.58, 27.31, 34.35, 17.64, 23.19 and 30.00%, respectively higher over thiourea, KCI and water spray.

Phosphorus uptake:-Grain:-Balanced fertilization:- Application of NPKS, NPKZn and NPKSZn increased P uptake in grain by the magnitude of 20.48, 13.36 and 25.12%, respectively as compared to NPK. While NPK increase it by 15.30% over N alone. Data further revealed that application of NPKSZn fertilization improved P uptake by grain by a margin of 10.37% over NPKZn.

Agrochemicals:-Data revealed that foliar application of brassinolide recorded significantly higher phosphorus uptake over rest of the agrochemicals tested, however, it was found remain at par with benzyladenine. The corresponding increases were in the order of 19.32, 22.81, 28.66, 16.48, 19.89 and 25.60%, respectively higher over thiourea, KCI and water spray.

Straw:-Balanced fertilization:-Application of NPKS, NPKZn and NPKSZn enhanced P uptake by straw 14.86, 7.94 and 21.62%, respectively over NPK. While NP fertilization bring 32.25% increment in comparison to N alone. Data further revealed that application of NP, NPK, NPKS, NPKZn and NPKSZn registered significantly 32.25, 46.90, 68.73, 58.56, and 78.66% higher in phosphorus uptake by straw N alone.

Agrochemicals:- Data revealed that foliar application of brassinolide recorded significantly higher P uptake by straw over rest of the agrochemicals tested, however, it was found remain at par with benzyladenine. The corresponding increases were in the order of 17.30, 25.32, 31.15, 14.01, 21.81 and 27.47%, respectively higher over thiourea, KCI and water spray. Data further revealed that foliar application of thiourea also recorded 11.80% significantly higher phosphorus uptake by straw over water spray.

Total P uptake:-Balanced fertilization:-Application of NPKS, NPKZn and NPKSZn increased total P uptake to the extent of 18.68, 11.62 and 24.00%, respectively as compared to NPK. While, NP fertilization bring 14.92% increment in comparison to N alone.

Agrochemicals:- Data revealed that foliar application of brassinolide recorded significantly higher total phosphorus uptake over rest of the agrochemicals tested, however, it was found remain at par with benzyladenine. The corresponding increases were in the order of 18.75, 23.58, 29.42, 15.77, 20.47 and 26.17% respectively higher over thiourea, KCI and water spray. Foliar application of thiourea also recorded significantly higher in total phosphorus uptake over water spray. The magnitude of increase was 8.98%.

Potassium uptake:-Grain:-Balanced fertilization:-Maximum K uptake recorded with NPKSZn, was significantly higher over rest of treatments, however, it was remained at par with NPKS. Further, NPKS and NPKZn were significantly superior over NPK. NPKS and NPKZn remained at par with each other. It was observed that K uptake in grain increase significantly due to NP and NPK fertilization over N. application of NPKS, NPKZn and NPKSZn increased K uptake in grain to the extent of 16.82, 11.03 and 22.51%, respectively as compared to NPK. While NPK and NP fertilization bring 19.42 and 12.39% in comparison to N alone, respectively.

Agrochemicals:-Data revealed that foliar application of brassinolide recorded significantly higher K uptake over rest of the agrochemicals tested, however, it was found remain at par with benzyladenine. The corresponding increases were in the order of 19.42, 22.14, 28.52, 15.78, 18.42 and 24.61%, respectively higher over thiourea, KCI and water spray. Data further revealed that foliar application of thiourea also recorded significantly higher in K uptake by grain over water spray. The magnitude of increase was 7.62%.

Straw:-Balanced fertilization:- Application of NPKSZn recorded maximum K uptake in straw which was significantly superior over rest of the treatments except NPKS. Further, NPKS and NPKZn also found significantly superior than NPK. However, both the treatments remained at par with each other.

Agrochemicals:- Data revealed that foliar application of brassinolide recorded significantly higher potassium uptake over rest of the agrochemicals tested, however, it was found remain at par with benzyladenine. The corresponding increases were in the order of 21.96, 29.70, 35.50, 19.18, 26.74 and 32.41%, respectively higher over thiourea, KCI and water spray. Foliar application of thiourea also recorded significantly higher in potassium uptake by straw by a margin of 11.10%.

Total K uptake:-Balanced fertilization:-Application of NPKS, NPKZn and NPKSZn increased total K uptake by 16.13, 9.95 and 21.11%, respectively as compared to NPK. Whereas NPK fertilization brings 34.10 and 7.56% increment in comparison to N and NP and NP fertilization registered 24.68% significantly higher in comparison to N alone.

Agrochemicals:- Data revealed that foliar application of brassinolide recorded significantly higher total potassium uptake over rest of the agrochemicals tested, however, it was found remain at par with benzyladenine. The corresponding increases were in the order of 21.59, 28.54, 34.43, 18.67, 25.45 and 31.21%, respectively higher over thiourea, KCI and water spray. Data further revealed that foliar application of thiourea also recorded significantly higher in total potassium uptake by the crop over water spray and registering 10.57 percent. However, foliar application of KCL was found remained at par with thiourea and water spray.

Sulphur uptake:-Grain:-Balanced fertilization:- Application of NPKS, NPKZn and NPKSZn increased S uptake in grain by 14.84, 8.67 and 21.25 per cent, respectively as compared to NPK. While NP fertilization

bring 12.92% increment in comparison N alone. Data further revealed that application of NPKSZn recorded 11.57% higher S uptake by grain over NPKZn.

Agrochemicals:-Data revealed that foliar application of brassinolide recorded significantly higher sulphur uptake over rest of the agrochemicals tested, however, it was found remain at par with benzyladenine. The corresponding increases were in the order of 15.48, 17.22, 22.42, 13.31, 15.02 and 20.12%, respectively higher over thiourea, KCI and water spray. Data further revealed that foliar application of thiourea also significantly recorded higher sulphur uptake by grain as compared to water spray and registered 6.00%.

Straw:-Balanced fertilization:- Application of NPKS, NPKZn and NPKSZn enhanced S uptake in straw to the extent of 1856, 8.66 and 26.48%, respectively over NPK. Whereas NP fertilization brings 34.69%, increment in comparison N alone. Data further revealed that application of NPKS also recorded significantly sulphur uptake by straw over N, NP and NPK by a margin of 68.41, 25.03 and 18.57%, respectively. Application of NPKZn recorded 16.40% higher sulphur uptake by straw over NPKZn.

Agrochemicals:-Data revealed that foliar application of brassinolide recorded significantly higher sulphur uptake over rest of the agrochemicals tested, however, it was found remain at par with benzyladenine. The corresponding increases were in the order of 14.55, 20.29, 25.76, 11.76, 17.36 and 22.71%, respectively higher over thiourea, KCI and water spray.

Total S uptake:-Balanced fertilization:-Application of NP, NPK, NPKS, NPKZN and NPKSZn increased total S uptake by 18.03, 23.18, 42.71, 33.88 and 51.10%, respectively as compared to N. Whereas NPKSZn fertilization brings 15.85, 8.68 and 22.66% increment to NPK.

Agrochemicals:-An examination of data present in Table 4.9 reveals that foliar application had significant improvement in total S uptake. The corresponding increases were in the order of 15.25, 18.01, 23.28, 12.90, 15.60 and 20.76%, respectively higher over thiourea, KCI and water spray. Foliar application of thiourea also significantly recorded higher total sulphur uptake by crop as compared to water spray and registered 6.97%.

Zinc uptake:-Grain:-Balanced fertilization:-Data further revealed that application of NPKSZn also recorded significantly higher Zn uptake by grain over NPKS and NPKSZn and registering 7.83 and 11.19%, respectively.

Agrochemicals:-An examination of data present in Table 4.9 reveals that foliar application had significant improvement in Zn uptake by grain. The corresponding increases were in the order of 18.27, 22.52, 29.45, 13.80, 17.89 and 24.56%, respectively higher over thiourea, KCI and water spray. Foliar application of thiourea also significantly recorded higher sulphur uptake by grain as compared to water spray and registered 9.45%.

Straw:-Balanced fertilization:-Data show that Zn uptake in straw was significantly enhanced over N alone due to balanced fertilization treatments. Application of NPKSZn recorded highest uptake, which was significantly superior over rest of the treatment. As compared to NPK, application of NPKS proved significantly superior. NPKS, NPKZn and NPKSZn fertilization increased Zn uptake in straw by the extent of 17.06, 13.24 and 25.95%, respectively over NPK.

Agrochemicals:-An examination of data present in Table 4.9 reveals that foliar application had significant improvement in Zn uptake by straw. The corresponding increases were in the order of 16.78, 25.21, 30.92, 13.32, 21.49 and 27.03%, respectively higher over thiourea, KCI and water spray. Data presented further revealed that during the course of study foliar application of thiourea also significantly recorded higher zinc uptake by straw over water spray and registering 12.10%.

Total Zn uptake:-Balanced fertilization:- Total Zn uptake was increased to the extent of 19.53, 15.81 and 28.80% due to application of NPKS, NPKZn and NPKSZn, respectively as compared to NPK. Increments due to NPK fertilization were by 8.47 and 22.53% as compared to NP and N and NP fertilization was by 22.53% as compared to N alone.

Agrochemicals:-An examination of data present in Table 4.9 reveals that foliar application had significant improvement in total Zn uptake by grain. The corresponding increases were in the order of 17.71, 23.53, 30.00, 13.62, 19.24 and 25.50%, respectively higher over thiourea, KCI and water spray. Foliar application of thiourea also significantly recorded higher sulphur uptake by grain as compared to water spray and registered 10.44%.

Effect of Balanced Fertilization and Agro-Chemicals on Protein Content:-In Grain:-Balanced fertilization:- Maximum protein content was recorded under NPKSZn followed by NPKS and NPKZn, which were significantly superior over N, NP and NPK. However, NPKS, NPKZn and NPKSZn treatments remained at par among them. As compared to N alone, NP fertilization significantly improved the protein content. Application of NPKS and NPKSZn increased grain protein content to the extent of 3.92 and 4.86% as compared to NPK.

Agrochemicals:-An examination of data present in table 4.10 reveals that foliar application had significant improvement in protein content in grain. The corresponding increases were in the order of 0.64, 0.92, 1.02, 0.45, 0.73 and 0.83 units, respectively higher over thiourea, KCI and water spray.

In Straw:-Balanced fertilization:-An examination of data presented in Table 4.10 clearly reveals that application of NPK, NPKS, NPKZn, and NPKSZn significantly improved the protein content in straw over N alone. NPKS, NPKZn and NPKSZn recorded significantly higher protein content over NPK alone and registering 12.00, 10.50 and 13.50% higher.

Agrochemicals:-An examination of data present in Table 4.10 reveals that foliar application had significant improvement in protein content in straw. Data revealed that foliar application of brassinolide recorded significantly higher protein content in straw over rest of the agrochemicals tested, however, it was found remain at par with benzyladenine. The corresponding increases were in the order of 9.27, 16.67, 17.28, 6.83, 14.06 and 14.66%, respectively higher over thiourea, KCI and water spray.

Protein Uptake:-Grain:-Balanced fertilization:-Maximum protein uptake by grain was recorded under NPKSZn followed by NPKS and NPKZn, which were significantly superior over N, NP and NPK. However, NPKS remained at par with NPKZn and NPKSZn. Application of NPKS, NPKZN and NPKSZn increase protein uptake by grain to the extent of 18.61, 11.80, and 24.17% over NPK.

Agrochemicals:-An examination of data present in Table 4.10 reveals that foliar application had significant improvement in protein uptake by grain. Data revealed that foliar application of brassinolide recorded significantly higher protein uptake by grain over rest of the agrochemicals tested, however, it was found remain at par with benzyladenine. The corresponding increases were in the order of 21.45, 25.42, 32.32, 17.77, 21.41 and 28.09%, respectively higher over thiourea, KCI and water spray. The data further revealed that thiourea also recorded 8.95% higher protein uptake by grain over water spray.

Straw:-Balanced fertilization:-Data presented in Table 4.10 reveals that application of NP, NPK, NPKS, NPKZn, NPKSZn fertilization significantly recorded higher protein uptake by straw over N alone, the magnitude of percent increase were in the order of 23.39, 39.94, 77.71, 65.53 and 86.93%, respectively. Data further reveled that NPKS, NPKZn, and NPKSZn recorded significantly 26.99, 18.28 and 33.57% higher over NPK alone.

Agrochemicals:-An examination of data present in Table 4.10 reveals that foliar application had significant improvement in protein uptake by straw. Data revealed that foliar application of brassinolide recorded significantly higher protein uptake by straw over rest of the agrochemicals tested, however, it was found remain at par with benzyladenine. The corresponding increases were in the order of 22.04, 34.14, 41.69, 17.92, 29.61 and 36.90%, respectively higher over thiourea, KCI and water spray. Foliar application of thiourea also recorded 9.91 and 16.09%t higher protein by straw over KCI and water spray.

Total Protein Uptake:-Balanced fertilization: Data depicted in Table 4.10 reveals that all the nutrients combination proved significantly higher total protein uptake over N alone. Maximum total protein uptake was realized under NPKSZn which was found at par with NPKS and significantly higher over rest of the treatments. Application of NPKS, NPKZn and NPKSZn recorded 20.47, 13.24, and 26.22% higher total protein uptake over NPK alone.

Agrochemicals:- The corresponding increases were in the order of 21.58, 27.31, 34.35, 17.65, 23.19 and 30.00%, respectively higher over thiourea, KCI and water spray, respectively. However, foliar spray of thiourea also recorded 10.50% higher total protein uptake over water spray.

Effect of Balanced Fertilization and Agro-Chemicals on Net Monetary Returns and B/C Ratio:-

Net monetary returns:-Balanced fertilization:-An examination of data revealed that all nutrient combinations provided significantly higher net returns over N alone. Data presented in Table 4.11 further revealed that as compared to N, application of NP, NPK, NPKS, NPKSZn and NPKSZn fetched 5879, 8011, 19834, 15234 and 23282 Rs ha^{-1}. The magnitude of percent increase to the tune of 10.69.14.57, 36.08, 27.71 and 42.34 percent over N alone. Application NPKS, NPKZn and NPKSZn provided additional returns of Rs. 11823, 7223 and 15271/ha^{-1}, respectively as compared to NPK.

Agrochemicals:-An examination of data present in Table 4.11 reveals that foliar application of brassinolide recorded significant higher net monetary gain. The corresponding increases were in the order of Rs 11819, 12458, 15586, 81162, 8755, and 11883 ha^{-1}, respectively higher over thiourea, KCI and water spray.

B/C ratio:-Balanced fertilization:- Application of NPKS, NPKSZn and NPKSZn recorded 17.71, 10.63 and 22.05% improvement in B/C ratio over NPK, NPKSZN and recorded 10.32% higher B/C ratio over NPKZn.

Agrochemicals:-An examination of data present in Table 4.11 reveals that foliar application of different agrochemicals had significant improvement in B/C ratio. The corresponding increases were in the order of 16.10, 16.98, 16.10 and 20.16%, respectively higher over thiourea, KCI and water spray.

Effect of Balanced Fertilization and Agro-Chemicals on available Nutrient status in soil after harvest the wheat crop:-

Nitrogen:-Balanced fertilization:-An examination of data revealed that all nutrient combinations provided significantly higher available nitrogen in soil after the harvest. Maximum available N was obtained with NPKSZn fertilization.

Agrochemicals:-An examination of data present in Table 4.12 reveals that foliar application of agrochemicals had no significant impact of on available soil N status.

Phosphorus:-Balanced fertilization:-An examination of data revealed that all nutrient combinations provided significantly higher available phosphorus in soil after the harvest. Maximum available phosphorus was obtained with NPKSZn fertilization.

Agrochemicals:-An examination of data presented in Table 4.12 reveals that foliar application of all the agrochemicals failed to exhibit significant improvement in P status in soil.

Potassium:-Balanced fertilization:-An examination of data show that all the balanced fertilization treatment improved available K content after harvest the wheat crop over N alone.

Agrochemicals:-An examination of data present in Table 4.12 reveals that foliar application of all the agrochemicals had no significant improvement in K content in soil after the harvest.

Sulphur:-Balanced fertilization:- Application of NPKSZn fetched maximum S content, which was found significantly superior over rest of the fertilization treatments except NPKS and NPKSZn.

Agrochemicals:-An examination of data presented in Table 4.12 reveals that foliar application of agrochemicals had significant improvement in S content in soil after harvest over water spray.

Zinc:-Balanced fertilization: An examination of data show that maximum Zn in soil after harvest in realized under NPKSZn. This level registering 0.12, 0.10 and 0.08ppm higher Zn over N, NP, and NPK.

Agrochemicals:-An examination of data presented in Table 4.12 reveals that foliar application of all agrochemicals had significant improvement in Zn content in soil after the harvest of wheat.

Table 4.1 Effect of balanced fertilization and agrochemicals on plant population and height

Treatments	Plant stands per m row length at 20 DAS	Plant height at harvest
Balanced fertilization		
N	34.73	71.71
N P	34.67	77.54
N P K	33.07	82.75
NPK + S	33.93	91.25
NPK + Zn	35.13	88.52
NPK + S + Zn	35.96	93.49
S.Em. ±	1.52	1.80
C.D. (P= 0.05)	NS	5.68
Agrochemicals		
Brassinolide (0.40ppm)	34.97	92.82
Benzylademine (45ppm)	36.09	89.54
Thiourea (1000ppm)	34.13	84.39
KCI (1000ppm)	32.90	79.45
Control (Water spray)	34.81	74.86
S. Em.±	1.06	1.59
C.D. (P = 0.05)	NS	4.53

Table-4.2-Effect of balanced fertilization and agrochemicals on dry matter accumulation

Treatments	Dry matter accumulation (g plant^{-1})				
	30 DAS	55 DAS	80 DAS	105 DAS	At harvest
Balanced fertilization					
N	9.04	60.24	112.32	135.93	178.34
N P	9.37	63.54	121.72	145.58	187.84
N P K	9.97	63.97	124.17	146.70	191.90
NPK + S	10.85	68.91	137.12	158.84	204.65
NPK + Zn	10.24	66.32	130.82	152.62	197.13
NPK + S + Zn	11.00	70.53	143.20	168.71	213.61
S.Em. ±	0.27	1.32	3.96	3.42	4.19
C.D. (P= 0.05)	0.86	4.15	12.49	10.77	13.19
Agrochemicals					
Brassinolide (0.40ppm)	10.10	69.83	138.46	163.16	206.38
Benzylademine (45ppm)	10.08	68.50	130.82	157.92	200.96
Thiourea (1000ppm)	10.06	64.62	125.27	148.50	194.86
KCI (1000ppm)	10.08	63.00	124.06	144.32	188.90
Control (Water spray)	10.07	61.97	122.51	143.09	186.79
S. Em.±	0.22	1.20	3.16	3.03	3.65
C.D. (P=0.05)	NS	3.41	8.97	8.60	10.37

Table 4.3 -Effect of balanced fertilization and agrochemicals on yield attributes

Treatments	Yield Attributes				
	Effective tillers m^{-1} row	Ear length (cm)	Grains ear^{-1}	Grain weight ear^{-1} (g)	Test weight (g)
Balanced fertilization					
N	85.11	9.82	28.95	1.49	35.60
N P	91.35	10.37	32.00	1.84	37.60
N P K	95.65	10.87	33.43	2.01	39.55
NPK + S	103.85	11.45	36.13	2.23	43.33
NPK + Zn	101.01	11.39	35.60	2.16	41.47
NPK + S + Zn	106.24	11.48	36.22	2.25	43.43
S.Em. ±	1.54	0.17	0.48	0.04	0.55
C.D. (P= 0.05)	4.84	0.52	1.51	0.13	1.75
Agrochemicals					
Brassinolide (0.40ppm)	103.48	11.69	36.12	2.27	43.14
Benzylademine (45ppm)	102.60	11.63	35.93	2.21	42.76
Thiourea (1000ppm)	97.20	10.87	33.49	1.97	39.95
KCI (1000ppm)	92.26	10.28	31.67	1.81	38.02
Control (Water spray)	90.45	10.01	31.40	1.73	36.94
S. Em.±	1.10	0.14	0.43	0.03	0.48
C.D. (P=0.05)	3.14	0.40	1.24	0.10	1.37

Table 4.4-Effect of balanced fertilization and agrochemicals on yield and harvest index

Treatments	Yield (kg ha^{-1})			
	Grain	Straw	Biological	Harvest index (%)
Balanced fertilization				
N	4067	5436	9503	42.73
N P	4393	6562	10955	39.99
N P K	4519	6895	11414	39.59
NPK + S	5147	7794	12941	39.82
NPK + Zn	4916	7381	12296	40.03
NPK + S + Zn	5333	8097	13429	39.75
S.Em. ±	114.7	170	239	0.70
C.D. (P= 0.05)	361.3	537	752	NS
Agrochemicals				
Brassinolide (0.40ppm)	5177	7690	12867	40.29
Benzylademine (45ppm)	5122	7585	12707	40.33
Thiourea (1000ppm)	4534	6850	11384	39.97
KCI (1000ppm)	4499	6614	11113	40.97
Control (Water spray)	4313	6397	10710	40.38
S. Em.±	98.6	129	204	0.44
C.D. (P=0.05)	280.4	368	579	NS

Table 4.5-Effect of balanced fertilization and agrochemicals on net returns and B/C ratio

Treatments	Net returns (Rs ha^{-1})	B/C ratio
Balanced fertilization		
N	54987	2.46
N P	60866	2.51
N P K	62998	2.54
NPK + S	74821	2.99
NPK + Zn	70221	2.81
NPK + S + Zn	78269	3.10
S.Em. ±	2003	0.08
C.D. (P= 0.05)	6310	0.27
Agrochemicals		
Brassinolide (0.40ppm)	75740	3.10
Benzylademine (45ppm)	72037	2.67
Thiourea (1000ppm)	63921	2.65
KCI (1000ppm)	63282	2.67
Control (Water spray)	60154	2.58
S. Em.±	1759	0.07
C.D. (P=0.05)	5001	0.20

Table 4.6-Effect on balanced fertilization and agrochemicals on nutrient content

Treatments	Nutrient content (%)					
	N		P		K	
	Seed	Straw	Seed	Straw	Seed	Straw
Balanced fertilization						
N	1.580	0.288	0.2638	0.0736	0.407	1.555
N P	1.655	0.297	0.2674	0.0810	0.424	1.645
N P K	1.714	0.320	0.2765	0.0858	0.439	1.687
NPK + S	1.781	0.359	0.2922	0.0871	0.450	1.730
NPK + Zn	1.759	0.353	0.2877	0.0865	0.448	1.729
NPK + S + Zn	1.797	0.364	0.2929	0.0886	0.456	1.733
S.Em. ±	0.015	0.003	0.0025	0.0009	0.004	0.016
C.D. (P= 0.05)	0.044	0.011	0.0080	0.0028	0.012	0.049
Agrochemicals						
Brassinolide (0.40ppm)	1.803	0.359	0.2902	0.0875	0.455	1.789
Benzylademine (45ppm)	1.773	0.351	0.2884	0.0865	0.447	1.776
Thiourea (1000ppm)	1.700	0.329	0.2785	0.0836	0.435	1.645
KCI (1000ppm)	1.655	0.308	0.2724	0.0811	0.427	1.602
Control (Water spray)	1.640	0.305	0.2711	0.0803	0.424	1.588
S. Em.±	0.012	0.003	0.0023	0.0006	0.003	0.012
C.D. (P=0.05)	0.034	0.007	0.0065	0.0017	0.009	0.035

Table 4.7-Effect of balanced fertilization and agrochemicals on nutrient content

Treatments	Nutrient content (%)			
	S (%)		Zn (ppm)	
	Seed	Straw	Seed	Straw
Balanced fertilization				
N	0.901	0.206	30.857	13.141
N P	0.950	0.232	34.282	13.949
N P K	0.956	0.232	35.630	14.741
NPK + S	0.966	0.244	37.883	15.248
NPK + Zn	0.956	0.237	38.481	15.575
NPK + S + Zn	0.983	0.250	39.365	15.773
S.Em. ±	0.007	0.002	0.226	0.113
C.D. (P= 0.05)	0.022	0.008	0.712	0.355
Agrochemicals				
Brassinolide (0.40ppm)	0.965	0.239	37.520	15.382
Benzylademine (45ppm)	0.957	0.237	36.695	15.173
Thiourea (1000ppm)	0.952	0.234	36.271	14.776
KCI (1000ppm)	0.944	0.230	35.154	14.241
Control (Water spray)	0.942	0.228	34.776	14.116
S. Em.±	0.003	0.001	0.181	0.093
C.D. (P=0.05)	0.010	0.004	0.516	0.264

Table 4.8-Effect of balanced fertilization and agrochemicals on nutrient uptake

Treatments	Nutrient uptake (kg ha^{-1})								
	N			P			K		
	Seed	Straw	Total	Seed	Straw	Total	Seed	Straw	Total
Balanced fertilization									
N	64.69	15.81	80.50	10.84	4.03	14.88	16.63	85.15	101.78
N P	72.90	19.51	92.41	11.77	5.33	17.10	18.69	108.21	126.90
N P K	77.51	22.13	99.64	12.50	5.92	18.42	19.86	116.63	136.49
NPK + S	91.93	28.10	120.04	15.06	6.80	21.86	23.20	135.31	158.50
NPK + Zn	86.66	26.18	112.84	14.17	6.39	20.56	22.05	128.02	150.07
NPK + S + Zn	96.21	29.56	125.77	15.64	7.20	22.84	24.33	140.97	165.30
S.Em. ±	2.30	0.62	2.65	0.37	0.17	0.44	0.53	2.70	2.99
C.D. (P= 0.05)	7.25	1.95	8.35	1.15	0.55	1.40	1.67	8.49	9.43
Agrochemicals									
Brassinolide (0.40ppm)	93.97	27.79	121.76	15.13	6.78	21.91	23.61	138.23	161.85
Benzylademine (45ppm)	90.96	26.85	117.82	14.77	6.59	21.36	22.89	135.08	157.96
Thiourea (1000ppm)	77.37	22.77	100.15	12.68	5.78	18.45	19.77	113.34	133.11
KCI (1000ppm)	74.92	20.72	95.64	12.32	5.41	17.73	19.33	106.58	125.91
Control (Water spray)	71.02	19.62	90.63	11.76	5.17	16.93	18.37	102.02	120.39
S. Em.±	1.84	0.45	2.12	0.27	0.11	0.34	0.43	2.49	2.74
C.D. (P=0.05)	5.24	1.28	6.02	0.78	0.30	0.98	1.23	7.09	7.78

Table 4.9 Effect of balanced fertilization and agrochemicals on nutrient uptake

Treatments	Nutrient uptake					
	S (kg ha^{-1})			Zn (g ha^{-1})		
	Seed	Straw	Total	Seed	Straw	Total
Balanced fertilization						
N	36.84	11.30	48.14	1261.0	717.8	1978.8
N P	41.60	15.22	56.82	1508.0	916.5	2424.6
N P K	43.25	16.05	59.30	1612.2	1017.7	2629.9
NPK + S	49.67	19.03	68.70	1952.3	1191.3	3143.6
NPK + Zn	47.00	17.44	64.45	1893.3	1152.4	3045.6
NPK + S + Zn	52.44	20.30	72.74	2105.2	1281.8	3387.1
S.Em. ±	1.15	0.42	1.40	43.2	26.4	60.7
C.D. (P= 0.05)	3.63	1.33	4.40	136.2	83.2	191.2
Agrochemicals						
Brassinolide (0.40ppm)	49.96	18.50	68.46	1958.4	1191.9	3150.3
Benzylademine (45ppm)	49.02	18.05	67.06	1884.4	1156.5	3040.9
Thiourea (1000ppm)	43.26	16.15	59.40	1655.9	1020.6	2676.4
KCI (1000ppm)	42.62	15.38	58.01	1598.4	951.9	2550.3
Control (Water spray)	40.81	14.71	55.53	1512.9	910.4	2423.3
S. Em.±	0.92	0.34	1.15	37.2	21.6	53.7
C.D. (P=0.05)	2.62	0.95	3.28	105.8	61.3	152.8

Table 4.10-Effect of balanced fertilization and agrochemicals on protein content and uptake

Treatments	Content (%)		Uptake (kg ha^{-1})		
	Seed	Straw	Seed	Straw	Total
Balanced fertilization					
N	9.88	1.80	404.29	98.84	503.13
N P	10.34	1.86	455.60	121.96	577.56
N P K	10.71	2.00	484.45	138.32	622.77
NPK + S	11.13	2.24	574.59	175.65	750.23
NPK + Zn	10.99	2.21	541.63	163.61	705.23
NPK + S + Zn	11.23	2.27	601.29	184.76	786.05
S.Em. ±	0.10	0.02	14.39	3.86	16.56
C.D. (P= 0.05)	0.31	0.07	45.34	12.71	52.18
Agrochemicals					
Brassinolide (0.40ppm)	11.27	2.24	587.30	173.70	761.00
Benzylademine (45ppm)	11.08	2.19	568.52	167.83	736.36
Thiourea (1000ppm)	10.63	2.05	483.59	142.32	625.91
KCI (1000ppm)	10.35	1.92	468.27	129.49	597.76
Control (Water spray)	10.25	1.91	443.85	122.59	566.45
S. Em.±	0.08	0.02	11.52	2.81	13.22
C.D. (P=0.05)	0.21	0.05	32.74	8.00	37.60

Table 4.11-Effect of balanced fertilization and agrochemicals on net returns and B/C ratio

Treatments	Net returns (Rs ha^{-1})	B/C ratio
Balanced fertilization		
N	54987	2.46
N P	60866	2.51
N P K	62998	2.54
NPK + S	74821	2.99
NPK + Zn	70221	2.81
NPK + S + Zn	78269	3.10
S.Em. ±	2003	0.08
C.D. (P= 0.05)	6310	0.27
Agrochemicals		
Brassinolide (0.40ppm)	75740	3.10
Benzylademine (45ppm)	72037	2.67
Thiourea (1000ppm)	63921	2.65
KCI (1000ppm)	63282	2.67
Control (Water spray)	60154	2.58
S. Em.±	1759	0.07
C.D. (P=0.05)	5001	0.20

Table 4.12-Effect of balanced fertilization and agrochemicals on nutrient status of soil after harvest the wheat crop

Treatments	Nutrients				
	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (kg ha^{-1})	Zn (g ha^{-1})
Balanced fertilization					
N	298.50	20.35	304.70	8.31	1.93
N P	324.20	22.11	322.90	9.57	1.95
N P K	324.92	22.57	322.58	10.21	1.97
NPK + S	330.06	23.53	332.52	10.51	2.00
NPK + Zn	333.96	23.78	332.70	10.56	2.04
NPK + S + Zn	343.53	24.44	333.84	10.81	2.05
S.Em. ±	4.69	0.45	4.45	0.16	0.03
C.D. (P= 0.05)	14.78	1.43	14.03	0.51	0.08
Agrochemicals					
Brassinolide (0.40ppm)	328.84	23.11	325.89	10.29	2.04
Benzylademine (45ppm)	328.55	22.91	324.13	10.29	2.01
Thiourea (1000ppm)	326.47	22.95	325.86	10.02	1.97
KCl (1000ppm)	323.00	22.60	325.77	10.02	1.98
Control (Water spray)	322.44	22.41	322.71	9.37	1.95
S. Em.±	3.84	0.33	3.99	0.13	0.02
C.D. (P=0.05)	NS	NS	NS	0.37	NS

CONCLUSION

Results emanated from the present experimentation revealed that wheat crop fertilized with NPKSZn (120kg N + 40kg P_2O_5 + 30kg K_2O + 40kg S + 5.5kg Zn ha^{-1}) proved superior for enhancing wheat productivity over rest of the nutrient combinations. This treatment recorded maximum grain yield (5333kg ha^{-1}), straw yield (80970kg ha^{-1}), biological yield (13429kg ha^{-1}), net returns (Rs-78269 ha^{-1}) with B/C ratio 3.10 with regards to agrochemicals, foliar application of brassinolide closely followed by benzyladenine recorded maximum grain yield (5177, 5122kg ha^{-1}), straw yield (7690, 7585kg ha^{-1}), biological yield (12867 and 12707kg ha^{-1}), net returns (Rs 7826975740 and 72037/ha^{-1}) and B/C ratio 3.10 and 2.67. However water spray recorded minimum value grain yield (4313kg/ha^{-1}), straw yield (6397kg/ha^{-1}), biological yield (10710kg/ha^{-1}), and net returns (Rs 60154ha^{-1}) with B/C ratio 2.58. However, these results are only indicative and need further experimentation to reach at more consistent and definite conclusion.

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