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# INTRODUCTION

Wheat is one of the world's most commonly consumed cereal grains. This comes from a type of grass (Triticum) that is grown in many varieties worldwide. Bread wheat or common wheat, is the most frequent species. Several other closely related species include durum, spelt, emmer, einkorn, and Khorasan wheat. Light and whole wheat flour are key ingredients in baked goods, such as bread. Other wheat-based foods include pasta, noodles, semolina, bulgur, and couscous. Wheat or grain is highly controversial as it contains a protein called gluten, which can induce a harmful immune response in predisposed individuals. Nevertheless , for folks who tolerate it, whole-grain wheat can become a rich source of various antioxidants, vitamins, minerals, and fibers. Botanically, the wheat or grain kernel is a type of fruit known as caryopsis. Wheat is cultivated on more land area than any other food crop (220. 4 mil hectares, 2014). World trade in wheat is better than for any other seeds combined. In 2016, world production of wheat was 749 million tonnes, so that it is second most produced food crop after maize.

Whole wheat is an important way to obtain carbohydrates (Shewry and Hey, 2015). Globally, it is the leading source of protein in human food, having a protein content of about 13%, which is comparatively high compared to other major cereals (CORDIS, 2016). Gluten, a sizable family of proteins, makes up about up to 80% of the total protein content. Just like all cereal grains, grain is mainly composed of carbohydrates. Starch is the predominant type of carbohydrate in the plant kingdom, and accounts for over 90% of the total sugars content in wheat. The fiber content of whole-grain wheat ranges from 12-15% of the dry weight. Whole grain may be a decent way to obtain several vitamin supplements and minerals, including selenium, manganese, phosphorus, copper, and folate. Wheat bran (present entirely wheat) may contain a range of healthy antioxidants, such as alkyl resorcinols and lignins. Several vitamins and other dietary minerals are in significant content. Whole wheat is 13% water, 71% carbohydrates, and 1.5% fat.

Next to rice, wheat is the main food-grain of India and is the staple food of millions of Indians, specifically in the northern and north-western parts of the country. India is the fourth most significant producer of wheat in the world after Russia, the United States and China and accounts for 8. 7 every cent of the planet's total production of whole wheat. Major wheat growing states in India are Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan, Bihar and Gujarat. Wheat is generally a crop of mid-latitude grasslands and requires a cool climate with average rainfall. The ideal wheat climate has winter temperature 10°C to 15°C and summer temperature varying from 21°C to 26°C. Wheat thrives well in areas receiving an annual rainfall of about 75 cm.

Micronutrients would be the chemical elements or chemicals required in trace portions for normal growth and development of plants. They will include boron, copper, straightener, manganese, molybednum, zinc, nickle and chloride (Allen and David, 2007). A shortage of any one of the micronutrients in the soil can limit the plant growth even when all the other nutrients are present in enough amount. Zinc is an important micronutrient required for the growth of wheat (Grundon, 1987) with crucial roles throughout the plant including in modification of carbohydrates, chlorophyll creation, the expansion harmone auxin and enzymatic reactions (Sauchelli, 1969). According to a Zn-staining study in whole wheat seed, Zn concentrations were found to be around 150 mg $kg^{-1}$ in the embryo and legumine layer and only 15 mg kg-1 in the endosperm (Ozturk et al., 2006). The Zn-rich regions of wheat seed are removed during milling, thus causing a marked reduction in flour Zn concentrations.

Zinc content in the soil generally differs from 10 to 300 ppm. A typical range of zinc in soils is 10-300 magnesium $kg^{-1}$ with anindicate of fifty mg Zn kg-1 (Kiekens, 1995). Undoubtedly Zn, for its concentration, can be considered as a trace aspect in garden soil. Zn deficiencies are frequently found the soils with the restricted root areas and specific zones. The movement of zinc to plant roots is dependent on the depth factors (concentration) and the capacity factors (ability to replenish). Zinc availability is highly dependent on ph level. If the pH is above 6, the supply of Zn is usually very low. The supply of Zn in alkaline soils is reduced thanks to reduce solubility of the soil Zn. The focus of Zn in the soil solution decreases from 10-4 (6.5 μg $g^{-1}$) to $10^{-10}$ M (0.007 μg $L^{-1}$) with an increase from pH 5 to ph level 8. Thus it is more probable that Zn deficiency will take place in alkaline rather than acidic soil (Alloway, 1995).

Zinc deficit in wheat appears as intervenial chlorosis on the most recently developed leaves; plants are stunted and produce few tillers; if the deficiency is severe the leaves may convert white and die. The most characteristic reactions of wheat plants to zinc deficiency are reductions in plant height and foliage size. These symptoms are followed by the launch of whitish-brown necrotic areas on middle-aged leaves. Because the severity of zinc deficiency intensifies, the necrotic spots spread on leaves, and the central parts of the leaves are often collapsed, displaying a "scorched" appearance. The universal deficiency of nitrogen and phosphorus is adopted by Zn deficiency.

Practically 50% worldwide soils used for cereal production is Zn deficient (Gibbson, 2006). Compared to soil Zn application, foliar application is more effective in increasing grain Zn content of wheat grown in potentially Zn-deficient calcareous soil. Plant growth regulators are important for growth and development of the crops. Plant growth regulators such as gibberallic acid, ethylene and cytokinin etc control several processes like department and elongation of skin cells and protein formation (Tiwari, 2011). PGRs can provide as an efficient measure for good germination, better growth, increased root length or high grain production in point seeded rice (Kaur, 2015). The major plant growth hormones are auxin and cytokinin. In higher plants, they control all the aspects of growth and development. Kinetin plays a significant and non-significant importance in shoot and root development respectively (Murari, 2014).

On consideration of above mentioned points we have planned present study to fulfill following objectives:

- To evaluate effect of zinc application methods on growth parameters and yield attributes of wheat.
- To study the effect of zinc application methods on zinc content in different plant parts.
- To study the effect of plant growth regulators (GA3 and Cytokinin) on translocation of zinc.

## REVIEW OF LITERATURE

*Triticum aestivum* L. commonly known as common wheat goes to kingdom plantae and family poaceae. Wheat is world's most widely developed food crop in India and second important staple cereal food. Wheat is staple food crop best for food security of South Asia including India (Joshi et al., 2007). As a rabi season (winter) crop, wheat performed essential role in stabilizing the food grain production in India. Wheat is grown since pre-historic times in the world. From all possible records, apparently their center of origin is South Western Asia. This is believed that Aryans brought wheat grains to India, and since then it has been grown in India.

Wheat is one of the main cereal crop in world and produced in around 230 Mha area worldwide which is 30 % of the world's cereal growing area with global production of 733 Mt. Currently, India is third leading maker of wheat in world after USA and Cina contributing about 13% share in total world wheat production. In India wheat is grown in 30 Mha area with production of 93 Mt (Economic survey, 2015).The average national productivity is about 2.98 t ha-1. But, India is lagging behind in productivity and holds sixth position in the world. Reasons for such a low productivity of grain in India are insufficient availability of quality seed, not enough scientific knowledge in farmers, limited water supply and frequent exposure to abiotic stresses like drought, high temperature and heat waves. Demand of grain increases at approximately 2% per year at global level due to growing population but increase in yield potential of wheat due to hereditary gain is less than 1% (Rosegrant and Cline, 2003).

The major wheat producing states in India are Punjab, Uttar Pradesh, Haryana, Madhya Pradesh, Rajasthan, Maharashtra, Bihar, Uttarakhand, Karnataka, Gujarat, West Bengal, Himachal Pradesh and Jammu & Kashmir. These claims contribute practically about 99 % of total wheat or grain production in the country. Remaining States, namely, Jharkhand, Assam, Chhattisgarh, Delhi and other North Eastern Areas contribute only about 0.5 % of the total wheat production in the country.

Climate is changing at an increasing pace in fact it is projected that the global temperature increase by the end of the 21st century is likely to exceed 1.5°C relative to the 1850 to early 1900s period for most cases and 2.0°C for many scenarios (IPCC AR5, 2014). Thus, problem of high temperature stress is expected to aggravate at a later date and will have large inference on wheat production. Comprehending the interaction of climate factors like high temperature/heat stress and food crops becomes essential for making strategies to counteract the impact of climate change. Plant hormones are important player in signal cascade active in the induction of plant stress responses (Farooq et al., 2011) as they play role in perception, transduction and induction phase of stress response.

Zinc is one of the seventeen essential elements necessary for the regular growth and development of plants. It is among eight micronutrients necessary for plant life. Zinc plays the role in plants with enzymes and proteins linked to carbohydrates metabolism, protein synthesis, gene expression, auxin (growth regulator) metabolism, pollen formation, and maintenance of biological membranes, protection against photo-oxidative destruction and heat stress, and resistance from infection by certain pathogens (Alloway, 2008).

Zinc is an essential plant micronutrient. It is vital for development of plant growth hormones and proteins which is engaged in sugar consumption. Good root development as well as carbohydrate and chlorophyll formation is also determined by zinc. Maintaining enough zinc levels is important for enabling plants to tolerate low air temperatures. Zinc is also involved in the synthesis of auxin, a plant hormone in order to determine whether to give attention to growing tall or becoming hairy. Tolerance to environmental stress conditions has a high requirement for Zn to manage and maintain the expression of genes needed to protect cells from the detrimental effects of stress (Cakmak, 2000).

Deficit of zinc can influence the plants in lots of ways such as stunted height, lower in tillers, smaller leaves, and increase in plant maturity time, bad quality of produce or products (Hafeez et al., 2013). Generally, the first symptoms of Zn deficiency in wheat show on the middle-aged leaves, but considerable deviation exists between individual plants; some plants produce symptoms in both old and middle-aged leaves simultaneously. These kinds of initial symptoms show a change in color from a healthy green to a muddy grey-green, generally in the central parts of the leaf. These foliage regions appear drought-stressed and necrotic areas, beginning with a tiny necrotic spot soon develop, little by little extending to the margins. As severeness intensifies, necrotic lesions pass on, and leaf blades take on a "scorched" appearance.

Zinc plays an important role in physical progress and development, functioning of disease fighting capability, reproductive health, physical function and neuro-behavioural development (Hotz and Brown, 2004). Recommended daily intakes range between 3 to 16 mg Zn/day, depending on age, gender, type of diet and other factors. It has been predicted that around 33% of the world's human population has diet deficient in Zn but this runs between 4 to

73% in several countries (Hotz and Brown, 2004). Heavy material deposition in the wheat crop was studied in two stages, one before flowering and after blooming. Regarding heavy metal accumulation in mg/g of dried part of plant, the tannery polluted wheat acumulate many folds heavy materials in several parts of wheat or grain like shoot, root and particularly in seeds in compare to the tubewell irrigated wheat which was clear from their mean values (Saggoo and Gupta, 2013). The concentration of Zn in several above-ground organs of grain was 9.5-112. 5 mg $kg^{-1}$ at different growing stages. The organ with the highest Zn concentration differed with the change of growth centre at different growing levels. Accumulation of Zn in leaf blades was the highest of most the organs during early growing period, and more than 50% of the Zn accumulation was distributed to leaf blades before jointing, and higher than that to other organs. In late growing period, however, the accumulation of Zn in grains was the highest, and 58. 1% of the Zn deposition was distributed in grains at maturity. The whole deposition of Zn in whole wheat plant during its life span ranged from 384. 9 to 475.9 g $ha^{-1}$. All organs were ordered in this sequence that leaf blades> spikes > leaf sheaths > stems according with their net absorption and travel of Zn as well as their contribution to Zn accumulation in grains. 58. 2-60. 3% of the Zn accumulated in grains was redistributed from other organs, mostly from leaf blades.

Concentration and accumulation of Zn in all the organs of wheat was high during early and middle growing periods, while accumulation of Zn in grains during late growing period mainly depended on the rate distribution from the other organs.

Yield is the ultimate outcome of all techniques involved at all phases in development and expansion of a crop, any one which may limit the yield of a particular crop (Munns et al., 2006). Yield and yield related parameters are improved by using zinc. Application of zinc significantly boosts the properties like test weight of grains, fat content, yield and protein content in wheat. Significant increase in development parameters, yield related characteristics and yield was discovered with zinc application Significant outcome was recorded for grain quality and yield from the key effects of nitrogen and zinc levels. Soil application and foliar application had significant result on almost all of the yield attributing characters of wheat. Foliar application of zinc was found effective for bettering the zinc percent in grains of wheat or grain. Best performance in respect to yield and nutrition quality of wheat was obtained from the foliar application of zinc. Significant influence on the starch content in the grains and straw was found but no effect was found on the protein content due the several rates and methods of Zn application (Hossain et al, 2008).

The main effect of methods of Zn application indicated that combined soil application + foliar spray of Zn fertilizer was most effective in increasing the grain Zn concentration followed by foliar application alone and the lowest increase was known with soil application of Zn. The highest piling up of Zn was documented with combined soil and foliar application of Zn followed by foliar application and least accumulation was noted with soil application of Zn. Zn application methods had a beneficial influence on grain yield, straw yield and total dried matter accumulation (Mathpal, 2015).

Zinc content in soil exists in a number of chemical forms with varying solubility. These forms include soluble Zn present in soil solution (water soluble), adsorbed on exchange sites (exchangeable), associated with OM, coprecipitated as secondary minerals or associated with sesquioxides (Almendros, 2008). These kinds of different forms mainly control solubility and availability of Zn to plants (Takrattanasaran et al., 2013). In addition, soil chemical properties such as pH, Rh, soil organic and natural matter (OM), have strong influence on Zn adsorption-desorption reactions and play a critical role in regulating Zn solubility and its fractionation in soil (Depar et al., 2011).

Applying Zn fertilizers to cereal crops improve not only productivity, but also grain Zn concentration of plants. Depending on the soil conditions and application form, Zn fertilizers can increase grain Zn concentration up to fourfold under field conditions (Bansal et al., 1990). All the Zn applied by different methods decreased the total P percentage. This may be attributed due to the antagonistic effect of Zn on P uptake. Application of P, not only decreased water-soluble and exchangeable-Zn, but also increased bound kinds of adsorption of Zn with soil particles (Iqbal, 2003).

The knowledge of translocation of Zn into various plant parts of wheat at various growth stages may be useful criterion in delineating the deficiency levels of nutrients from sufficiency and toxicity levels. Nutrient content in various parts of plant can assist in evaluating the nutrient status of crops. The higher the capacity for a plant to accumulate a nutrient, the greater would be the difference in the nutrient concentration in response to varying rates of fertilizer application. Generally, the concentration of micronutrients cations will not vary greatly within plants parts, however, application of nutrient(s) in question may alter the concentration of other micronutrients at some extent which may impact their critical level in the plant parts. Knowleadge of Zn transport in plant is inadequate. Little is known about transfer of Zn from root base to shoots and from shoots to other plant parts. Zn absorption by plants involves a quantity of steps (Lasat et al., 1998). First, adequate Zn bioavailability was necessary in the rhizoshpere. Right now there are two pathways for Zn to move from the soil solution to the rhizosphere, mass flow and diffusion. Zn transfer in plants takes place through both xylem and the phloem. Following observation by the roots, Zn is rapidly transported via the xylem to the shoot (Riceman and Jones, 1958). It has been claimed that the Zn moved from phloem does not occur in wheat, departing roots starved of Zn if not supplied in root environment. Nevertheless , more recent studies with wheat or grain showed good transport of Zn from stem and leaves to developing wheat, as well as in one root to another, suggesting involvement of phloem transportation.

The yield of whole wheat significantly gets higher in all methods of zinc application. Soil dressing of zinc gave the maximum yield which was more than the plots with root dipping and foliar application. Significant increase in the zinc content of the soil was found by all different methods of zinc application after the harvest of the crop (Khan et al., 2003). With increase in N and Zn levels, all the yield components significantly increased (Masum et al, 2013). Effects of foliar Zn application may be because of its role in crop growth (Cakmak, 2008) involving processes of the natural photosynthesis, nitrogen assimilation, respiration and activation of other biochemical and physiological processes and hence their importance in obtaining greater yields. This is noteworthy also that Zn translocation applied to leaves will depend on the plant nutritional status (Martinez et al., 2005). Thus, it can be inferred that because of the high micronutrient supply in the soil, there was greater use and Zn translocation applied to wheat leaves. Foliar software of zinc increased the quantity of fertile tillers.

Significant accept the yield and expansion was observed by the usage of zinc for two months. Zn application significantly increased the quantity of tillers and quantity of grains per panicle. Improved enzymatic activity and auxin metabolic is found by the zinc application (Babar, 2013). Significant increase in the plant growth, chlorophyll content and yieldS attribute was found by the use of gibberellic acid and kinetin. Spray of gibberellic acid and kinetin significantly increase solute accumulation, growth and higher grain assimilate deposite. PGRs can indirectly customize plant's natural hormonal activity. As a consequence, there are reports in the scientific literature of PGRs increasing root growth and yield. In the flip side, you can also get reports of PGRs increasing plant height, creating late tillering and yield reduction (Sheri Strydhors, 2014).

Plant progress regulators have significant influence on morhological and physiological attributes of wheat. A minor concentration of PGRs may lead to faster progress and development of the plant. Kinetin decreased leaves senescence and improved the grain yield. GA3 revealed the maximum yield in relation to all other treatments (Kaur, 2015). GA3 is an important individual growth hormone and significantly effects the morphological and yield characters of wheat. Application of GA3 increased the seed set and seed production by increasing the panicle exertion. Amazing increase in plant level, panicle exertion and duration of floret opening was obtained by the application of GA3. GA3 application increased the yield by 0. 2 to 1 t/ha. GA3 gave the best results for grain yield as compared to all other treatments in all the lines (Susilawati, 2014). Plant growth regulators, gibberellic acid and kinetin had positive effect on nutrient content and nutrient uptake in plants. Kinetin and gibberellic acid helps in the translocation of the nutrition into different plant parts. Gibberellic acid and Kinetin can significantly improve the Zinc, iron and manganese content in the barley than control. Zinc content in barley is highest in GA3 than kinetin and control. Nutrient uptake from the roots can be increased by the application of gibberellic acid (Akman, 2009).

Plant growth regulators play an important role in the growth and development of the plants. Plant heightl significantly increased by the foliar application of gibberellic acid than the cytokinin and the control (Leite, 2003). Spray of gibberellic acid and kinetin significantly increased solute accumulation, development and higher grain assimilate deposite. Yield and quality of the wheat was significantly influenced by the application of zinc. Both of the method of zinc application, soil and foliar spray significantly increased the test weight, grain yield and protein content of wheat. Combined application of soil and foliar spray gave better grain protein content in wheat followed by soil, foliar over the control (Khattak, 2015). Different zinc application methods had significant positive influence on the yield and quality of the wheat crop. Significant increase in the grain zinc content of wheat was noticed when the soil application and foliar spray method of zinc application were applied. Combined application on ground and foliar spray significantly increased the grain yield and straw yield over the control (Mathpal, 2015).

The final grain give of wheat involves 3 main components, namely, the number of spikes per ground unit, the quantity of grain per spike, and 1, 000 grain weight, and ach component is shaped throughout a specific stage of wheat growth and development (Itoh et al., 2006). Plant hormones influence mobilization of inorganic plant nutrients and sugar. Most experimental evidence that indicates plant hormones affect nutrient mobilization or translocation within plants comes from short term laboratory studies. Gibberellic acid stimulates phosphatic uptake into corn root cells, potassium uptake in wheat, and sulfate translocation from root to take in pea seedlings. Nutrient uptake is an extravagant process with many interacting factors and is difficult to influence by foliar or soil application of low concentrations of PGRs. Nutrient uptake in field cropss from the soil is damaged by eleven factors relating to both plant and soil parameters (Barber, 1984). Nutrient concentrations in plant parts were a bit increased, slightly decreased, or not afflected by growth stimulants. Nutrient concentrations in crops were increased to a greater extent by fertilizer additions than by the usage of growth stimulants (NCR-103 Committee, 1976).

Plants take up zinc in their divalent form. At this time it still remains unclear whether this uptake is facilitated as diffusion through membranes specific for zinc ion or whether it be mediated by specific transporter(s). It has been concluded that both mechanisms operate, and about 90.5 per cent of the total zinc required by plants moves towards the roots by the diffusion. This lateral movement of zinc is highly centered after the soil wetness, and this might be the reason why, particularly in dry and semi-arid areas, zinc deficiency is more frequently seen. Zinc is carried in the xylem cells from the roots to the shoots. However, high amounts of zinc have recently been detected in the phloem tissues, which indicates that zinc moves through both transport tissues, and maybe remobilisation of zinc towards the grain during ripening. Substantial translocation of zinc takes place from the older leaves to the younger ones during wheat development phase. Plants lacking in nitrogen do not show the retranslocation of zinc from the more mature leaves, indicating that the deficiency symptoms of zinc will be more pronounced in the nitrogen deficient plants.

Gibberellins being one of the important and primary plant harmone have physiological functions such as stimulating organ growth through enhancement of cell elongation and cell section; they also act as developmental switch between seedling dormancy and germination, teen and adult growth stages, and vegetative and reproductive development. Gibberellins have very important role in pollen fertility, 13 stamen elongation, release and germination of pollen and for pollen tube growth etc.

Exogenous gibberellins may act by regulating the level of active gibberellins in the plant (Tonkinson et al., 1997). Exogenous application of GA3 an active gibberellins in plants was able to overcome the inhibitory result of abiotic stress like salt, oxidative, and cold stresses in the germination and seedling establishment of maize, mustard and wheat or grain (Yang et al., 2013).

Cytokinins (CK) are known to stimulate or hinder a great number of physiological processes. Cytokinins take part in cell division, cellular enlargement, senescence and transportation of amino acids in plants. For the specific regulation of many plant processes and the differentiation of cells into specific plants parts, a variety of ratios and concentrations of plant growth regulators are required.

# Materials and methods

**(A). Name of experiment:** To study the effect of various methods of zinc application on yield and quality of wheat (*Triticum aestivum* L.).

**(B). Location**: The experiment will be conducted on Agricultural Research Farm, LPU, Phagwara.

Different zinc application methods will be used as per plan of the experiment.

**(C). Experimental Details:**

1. Year of experimentation : 2017-19
2. No. of factors : 3
   a. Varieties
   b. Zinc application methods
   c. Plant growth regulators
3. No. of levels
   a. Varieties: 2
   b. Zinc application methods
   c. Plant growth regulators

| | | |
|---|---|---|
| 4 | No. of treatments | :9 |
| 5 | No. of varieties | :2 |
| 6 | No. of replication | :3 |
| 7 | Total no. of pots | :54 |
| 8 | Experimental design | :Factorial completely randomized design |
| 9 | Crop | :Wheat |

**(E). Collection of soil samples:** Soil samples will be taken before crop sowing to check the soil pH, organic carbon, electric conductivity, N, P, K and Zn ratio present in soil.

**(F). Observations:** Observations will be recorded in relation to-

1. Morphological and biochemical characters
2. Yield
3. Yield attribute

**(G). Analysis:** Soil analysis

Initial soil: Initial soil samples will be analyzed for pH, EC, Organic C, available N, P and K and zinc amount present in the soil.

**Analytical methods to be followed during investigation are as under**

| **S. N.** | **Test parameter** | **Method** | **References** |
|---|---|---|---|
| 1 | pH (1:2.5) | Glass electrode | Sparks (1996) |
| 2 | EC (1:2.5) | Conductivity meter | Sparks (1996) |
| 3 | Organic C | Wet digestion | Walkley and Black (1934) |
| 4 | Available N | Alkaline potassium permanganate method | Subbiah & Asija (1956) |
| 5 | Available P | Olsen’s Method | Olsen *et al*. (1954) |
| 6 | Available K | Flame photometer | Jackson (1973) |
| 7 | Zinc | *Atomic Absorption Spectroscopy* | Walsh (1955) |

**(H). Study will be conducted in the following manner**

- Morphological parameters at different stages of crop.
- Concentration of micronutrient (Zn) in leaves, stem and grains parts.
- Estimation of total chlorophyll content.
- Grain yield and straw yield.

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