Soyabean or soybean is botanically known as *Glycine max* (L.) Merill which is one of the oldest legumes in the history of crop cultivation and belongs to the family Fabaceae. It is native of China and was introduced to India in 1968 from USA.

Soybean occupies an important position among the grain legumes due to its economic importance. It is also known as the “Golden bean” or “Miracle crop” because of its multiple uses. Its oil has the largest share in global edible market. Due to its high protein content, soybean is known as “Poor man’s meat” and “complete protein” on par with meat, milk products and eggs. Commercially important products which are commonly made from soybean include protein powders, soybean vegetable oils, dry beans, sprouts, livestock feed, gluten-free flour, multo, tofu, soy milk, soy cheese and curds. Along with it soy products have also shown to be beneficial in reducing the risk of certain disease including heart disease and certain cancers.

As the soybean demand increases, the supply is challenged, the stock reduces and the market price rise. In order to meet the demand, there are two alternative source-increase plants per hectares or increases yield (ton/ha). World-wide harvested areas of soybean increased over 60% while yield increased less than 30% since 1990. Soybean production therefore will require research and development to increase yields in order to meet future demand and compensate for declining stocks of available land. At present, soybean occupies an area of 91.4 m ha in the world with a production of 204 m tons and productivity of 2233 Kg/ha (USDA, 2016). Of all the soybean producing countries, the United States occupies first place, which produced 80.6 million tons (35.0%) followed by Brazil, who produced 53.9 million tons of soybean (31%). Argentina is the third largest producer and produced 41.4 million tons (17%), followed by China whose production stood at 15.8 million tons (4.02%) (Fig.1.1). At present, India ranks fifth in the area and production in the world after USA, Brazil, Argentina and China.

In India soybean is cultivated in five major states of Madhya Pradesh, Maharashtra, Rajasthan, Karnataka and Andhra Pradesh (Fig. 1.2). Madhya Pradesh is the leading soybean producing state contributing about 58% followed by Maharashtra which contribute about 30% while Rajasthan contribute about 7% to India’s total soybean production (FAO, 2016).
The contribution of India in the world soybean area is 10% but the contribution to total world soybean production is only about 3% indicating the poor level of productivity of the crop in India (1.1 t/ha) as compared to other countries (world average 2.2 t/ha). It is grown over an area of 12.20 m ha with production of 11.99 m tons and overall yield of 983 Kg/ha (Agricultural statistics 2014, GOI).

The reasons for low productivity of this crop are large scale cultivation on rainfed area and low input conditions. The major physiological constraints which limit productivity are lack of seedling vigour, slow development of leaf area during first eight weeks after planting, profuse flowering but poor seed set, limitation of source at the time of seed development due to early leaf senescence, inefficient mobilization of
carbon and nitrogen etc. Area under cultivation has been increased rapidly from 2003-04 (65 lakh hectares) to 2012-13 (85 lakh hectares) which lead to increase in the production of soybean from 2003-04 (78.18 lakh tones) to 2012-13 (146.66 lakh tonnes) (Fig.1.3).

![Production of Soybean in India](image)

**Fig 1.3. Production of Soybean in India (FAO reports, 2016)**

It is important to note that although production of soybean is increasing, yet it remain far away from average value due to number of reasons:-

1. Agroclimatic conditions (early end to monsoon resulting in water stress during pod filling).
2. Lack of cultivation techniques
3. Government policies (inaccessibility of inputs such as seed, fertilizer, pesticides)
4. Research (lack of region specific, high yielding varieties due to inadequate research.

It is thus important to consider the future prospects for continued high return for soybean.

Among the various advantages and high yielding potential of soybean, the yield per unit area is low which indicate that there is a great scope for improving the productivity potential by using suitable measures, particularly the use of plant growth regulators (PGRs). To meet the challenges resulting from environmental stresses and increasing population, the “National food security mission” initiated by the government of India has stressed upon the understanding mechanisms for crop production. Although, extensive research has been undertaken regarding the role of classical
phytohormones efficiency in exploiting crop enhancement to the optimum level. However in the recent years, a new class of plant hormones like salicylic acid (SA), brassinosteriods (BR’s) and jasmonates (JAs) are recognized as the potent phytohormones and stress alleviators against various biotic and abiotic stress.

Plant growth regulators (PGR’s) are organic compounds other than nutrients that affect plant growth and development by affecting their physiological processes. PGR’s may be naturally occurring plant produced chemicals called hormones or may be synthetically produced compounds. PGR’s are called biostimulants or inhibitors, specific enzymes or enzyme systems that help in regulation of plant metabolism. Most PGR’s are natural or synthetic and fall into following classes- Auxins, gibberellins, cytokinins, ethylene, abscisic acid, salicylic acid, jasmonic acid and brassinosteriods.

Salicylic acid (SA) is a phenolic compound which despite its broad distribution in plants, has basal levels differing widely among species. In recent years SA has been the focus of intensive research due to its function as an endogenous signal mediating local and systemic plant defence responses against pathogens. It has also been found that SA plays a role during the plant response to abiotic stresses such as drought, chilling, heavy metal toxicity, heat and salinity stress. Salicylic acid plays a crucial role in the regulation of physiological and biochemical processes during the entire life span of the plant. However, the effect of SA on plant resistance to abiotic stresses usually contradicts with each other. The same pre-treatment with exogenous SA results in opposite site responses in different plant species (Yang et al., 2004).

Furthermore, interaction between different hormones is an essential part of regulation during plant development (Leopold and Nooden, 1984). Salicylic acid altered the auxin, cytokinin and ABA balances in wheat and increased the growth and yield under both normal and saline conditions. Increased yield under foliar application of salicylic acid could be ascribed to the positive effects of salicylic acid on photosynthetic parameters and plant water relations.

Jasmonic acid (JA) and its methyl ester, methyl jasmonate (MeJA) are naturally occurring plant growth regulators which can affect many physiological and biochemical processes in plants (Wang et al., 2009). JA is a also critical signaling molecule for diverse developmental processes and defense responses in plants (Kazan and Manners, 2012). Recent molecular studies have demonstrated the biological relevancies of JA in salt stress tolerance. Interestingly, similar to ABA, the accumulation of endogenous JA
level was reported in salt tolerant cultivar crop compared to salt-sensitive cultivars (Kang et al., 2005).

There are strong evidences for considering brassinosteroids (BRs), a group of steroidal substances first isolated from the pollen of *Brassica napus* (Grove et al., 1979) as the sixth group of plant hormones. Since the discovery of BL about 70 BRs have been indentified and fully characterized (Bajguz and Tretyn, 2003) and among these, three natural brassinosteroids namely brassinolide (BL), 24-epibrassinolide (24-EBL) and 28-homobrassinolide (28-HBL) are known to have significant effect on plant metabolism, growth, productivity and experience high stability under field condition (Khripach et al., 2000, Rao et al., 2002). Several studies have established that BRs influence seed germination, plant growth, nitrogen fixation, senescence, leaf abscission, increased yield, fruit ripening and enhanced tolerance against various abiotic/biotic stress like chilling, drought, thermal, heavy metals, pesticide, salt and diseases (fungal, viral and bacterial infection (Ali et al., 2007; Hayat et al., 2007). As a consequence, extensive research has been undertaken to develop BR as plant growth regulators for agricultural production (Ozdimer et al., 2004).

Plants responds to various abiotic or biotic stresses by a range of potential mechanism the scavenging of the toxic reactive oxygen species (ROS) produced during stress. To do so, plants are equipped with an efficient antioxidative defense system which includes both non-enzymatic and enzymatic scavenging system. Usually the production of ROS is enhanced with a parallel increase in antioxidants, there by suggesting that the antioxidative defense system may have a general role in the protection of plants under stress condition (Nunez et al., 2003). Phytohormones like ethylene, jasmonate, abscisic acid, salicylic acid and BRs have been reported in modulating plant responses to oxidative stress (Xiong and Zhu, 2002; Cao et al., 2005)

So from above literature it can be concluded that Plant growth regulators emerged as “magic chemicals” that could increase agricultural production at an unprecedented rate and help in removing the barriers which are imposed by genetics or any type of environmental stresses. Plant growth regulators when added in small amounts can modify the natural growth regulatory system right from seed germination to senescence in several crop plants. Plant growth regulators (promoters, inhibitors or retardants) play key role in contributing internal mechanisms of plant growth by interacting with key metabolic processes such as, nucleic acid metabolism and protein
synthesis. So, the aim of the present study is to enhance the production of soybean by the foliar application of different PGRs.

**OBJECTIVES OF THE STUDY**

From the review of literature above it appears that there is a large variation in growth and developmental studies in legumes with respect to plant growth regulators and moreover, effect of PGRs on antioxidant metabolism needs further investigations. The present study is aimed to make a comparative assessment of different PGRs for improvement in the production of soybean. The following would be the objectives of the present study:

1. To study the influence of some plant growth regulators (PGRs) on yield attributes on Soybean.
2. To study the influence of some plant growth regulators (PGRs) on morphological and biochemical changes.
3. To determine the influence of exogenous PGRs on the status of antioxidant enzymes during different developmental stages.
4. To evaluate the effect of interaction of above mentioned PGRs in regulation of growth and development in Soybean.