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EFFECT OF THIOUREA AND SALICYLIC ACID IN ENHANCING GROWTH AND PHENOLOGY OF MUNGBEAN (*VIGNA RADIATA* (L.) R. WILCZEK) FOR QUALITY SEED PRODUCTION

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ABSTRACT

Under Kharif sowing, the mung bean production area is drastically decreasing due to various environmental constraints. The crop faces frequent water-logging and drought due to the uneven rainfall distribution due to climate change. This climate change effect leads to a drastic change in phenology and quality seed production. PGR has the potential to alleviate the devastating effect of biotic stress and abiotic stress, as evident from a study concluded on various field crops. Besides that, due to variation in environmental factors, endogenous hormone level fluctuates, which leads to phenological changes in plants and also deteriorates the seed quality. Hence, we tested our hypothesis that exogenous application of Salicylic acid and thiourea will maintain endogenous hormone levels, which maintains source-sink balance and hence seed quality under Kharif sown condition. The research revealed that thiourea @250 ppm leads to enhanced seed germination and vigor due to enhancement in Seed germination (85.33%), Seed vigor index – I (2836.98) and Seed vigor index – II (1.90) with respect to 86.19%, 183.01% and 4.39% superiority over control, respectively. This proves our hypothesis. Hence, thiourea @250 ppm is recommended to mung bean growing farmers for better growth, development and enhanced seed quality under Kharif sowing.
***Keywords*: ** Plant growth regulators, Thiourea, Salicylic acid, Mungbean.

Introduction

India is the major producer of green gram (Mungbean) in the world with about 4.5 million hectares under cultivation with a total production of 2.5 million tonnes with a productivity of 548 kg ha^{-1} and contributing 10 % to the total pulse production. According to Government of India estimates, green gram production in 2020-21 is at 2.64 million tonnes. In Madhya Pradesh during Twelfth five-year plan (2012-2017), the total area covered under Mungbean was 2.51 lakh ha with 1.16 lakh tonnes total production, and productivity was 464 kg ha^{-1} (Annual Report DPD 2016-17). The low productivity is due to abiotic and biotic constraints, poor crop management practices, and the non-availability of quality seeds of improved varieties to farmers (Pratap *et al.,* 2019a). The major biotic factors include diseases such as yellow mosaic, anthracnose, powdery mildew, cercospora leaf spot (CLS), dry root rot, halo blight, and tan spot, and insect pests, especially bruchids, whitefly, thrips, aphids, and pod borers (Pandey *et al.,* 2018). Abiotic stresses affecting mungbean production include waterlogging, salinity, heat, and drought stress (Rao *et al.,* 2016). Plant growth substances enhance the source-sink relationship and stimulate the translocation of photo-assimilates to sink, thereby helping in effective flower formation, fruit, and seed development, ultimately enhancing the productivity of crops (Ammanullah *et al.,* 2010).

Thiourea, an analogue of cytokinin, is a potential plant growth regulator that improves stress tolerance potential in plants. Exogenous application of thiourea enhance the growth and productivity. Thiourea, an organosulfur compound with the formula $SC(NH_2)_2$, is structurally similar to urea, except that a sulphur atom replaces the oxygen atom. However, the properties of urea and thiourea differ significantly. Thiourea is a reagent in organic synthesis. Physiologically, thiourea offsets the effect of ABA and increases the level of Cytokinin in plant tissues subjected to water stress due to drought, salinity, or supra optimal temperatures (Srivastava *et al.,* 2010). Thiourea treatment effectively promotes germination when dormancy is related to salt or water stresses (Khan and Ungar, 2001). Being water-soluble, readily absorbable in the tissues, and capable of ameliorating stress effects; thiourea could be used to improve yield under abiotic stresses (Devi *et al.,* 2015)

Salicylic Acid (SA) is a Lipophilic mono hydroxybenzoic acid, phenolic acid, β-Hydroxy acid ($C_7H_6O_3$), and a growth regulator that promotes photosynthesis under heat stress by influencing various physiological and biochemical processes in plants. It plays diverse physiological roles in plants, including thermogenesis, flower induction, nutrient uptake, ethylene biosynthesis, stomatal movement, photosynthesis, and anti-oxidative enzymes (Hayat *et al.,* 2007). It stimulates flowering in a range of plants, increases flower life, controls ion uptake by roots and stomatal conductivity. Salicylic acid regulated plant physiological processes such as photosynthesis, nitrogen and proline metabolisms, glycine betaine production, and antioxidant enzyme activity (Nazar *et al.,* 2011; Miura and Tada, 2014) and improved plant tolerance to abiotic stresses such as salinity (Khan *et al.,* 2014; Nazar *et al.,* 2015).

We proceeded our study with the hypothesis that thiourea and salicylic acid will increase the net productivity by efficient pod filling and assimilate partitioning.

Material and Methods

The phenological observations were noted from three selected and tagged plants throughout the growth period through daily visual observations. Days required to first flowering from sowing were counted and expressed as the days to first flowering. The day on which 50% of plants showed flowering in the plot was considered as 50% flowering. The number of days taken from the date of sowing to 50% flowering was calculated and expressed in number as days taken for 50% flowering. The day on which plants showed start of pod formation in the plot is considered as pod initiation. The number of days taken from sowing to pod initiation was calculated and expressed in number as days taken for pods initiation. Days to physiological maturity was recorded as the number of days taken from the date of sowing to physiological maturity.

The seed quality traits were determined from the harvested crop seeds using Seed Germinator in the seed technology research centre, JNKVV, Jabalpur. Germination percentage (%) was calculated using three replications of 100 seeds from respective treatments which were used for germination by using between paper methods (BP) at 25 ± 20 °C in seed germinator for 8 days at 90% relative humidity (Anonymous, 1999). The seeds were categorized as normal seedlings, abnormal seedlings, hard seed, and dead seed. The germination percentage was recorded based on normal seedlings only. For seedling length, ten normal seedlings were selected randomly in each treatment from all the replications on eight days from the germination test. The seedling length was measured from the tip of the primary leaf to the base of hypocotyls with a scale's help, and the mean seedling length was expressed in cm. For seedling dry weight ten normal seedlings used for root and shoot length measurements and kept in a hot air oven at 50±10C for 24 hours. The dry weight of the seedlings was recorded and expressed in grams.

Seedling vigour index I was computed by adopting the formula as suggested by Abdul-Baki and Anderson (1973) and expressed as an index number.

Vigour Index-I = (Root length (cm) +Shoot length (cm)) × Germination %

Seedling vigour index II was computed by adopting the formula as suggested by Abdul-Baki and Anderson (1973) and expressed as an index number.

Vigour Index-II = Seedling dry weight (g) × Germination percentage

Result and Discussion

Phenophases

Table 1 : Effect of plant growth regulators on phenology of mungbean crop.

Treatments	Days to flower initiation	Days to 50% flowering	Days to pod formation	Days to physiological maturity
(Control)	32.33	39.00	47.00	60.67
Th @ 250 ppm	33.00	40.00	46.00	60.00
Th @ 500 ppm	32.67	39.33	49.33	62.67
Th @ 1000 ppm	33.33	40.00	46.67	60.00
Th @ 1500 ppm	29.67	36.67	45.33	61.00
SA @ 250 ppm	30.33	36.33	45.67	61.00
SA @ 500 ppm	30.33	36.67	44.00	59.67
SA @ 1000 ppm	29.00	35.67	41.67	57.00
S.Em	0.9990	0.6315	1.5059	1.1046
CD	3.0302	1.9155	NS	NS

Days to flowering is an important phenological parameter determining the yield potential of mungbean. Early flowering is an important attribute for crops during abiotic stress particularly drought stress and heat stress (Anbessa *et al.,* 2006). Late flowering leads to maximum vegetative growth i.e., source activity which supports maximum yield through increased photosynthetic assimilates production. Thiourea @1000 ppm being a cytokinin analogue enhances days to flowering because cytokinin enhances source activity through increasing cell division, chloroplast development, and maturation, delaying leaf senescence. Significant difference was observed for treatment ($P \geq 0.05$). The days to flower initiation ranged between 29 DAS to 33.33 DAS. Foliar spray of Thiourea @ 1000 ppm took maximum days for flower initiation (33.33 DAS) followed by foliar spray of Thiourea @ 250 ppm (33.33 DAS). In contrast, foliar spray of SA @ 1000 ppm took minimum days for flower initiation (29 DAS).

The days to 50% flowering ranged between 35.67 DAS to 40 DAS. Foliar spray of Thiourea @ 250 ppm and foliar spray of Thiourea @ 1000 ppm took maximum days for 50% flowering (40 DAS) followed by foliar spray of Thiourea @ 500 ppm (39.33 DAS). In contrast, foliar spray of SA @ 1000 ppm took minimum days for 50% flowering (35.67 DAS). Zubair *et al.* (2007) concluded that correlation results revealed that days to flower initiation and days to 50% flowering had significant positive association with days to maturity, pod length and harvest index.

Pod formation is responsible for enhancing the crop yield, as the pods are the photosynthetically active units, which contributes 50-60% of the dry matter of mature plants. Pod formation influences the seed size positively. The early pod formation increases the assimilation of nutrients that fuels seed growth. The days to pod formation ranged between 41.67 DAS and 49.33 DAS. Foliar spray of Thiourea @ 500 ppm took maximum days for pod formation (49.33 DAS) followed by control (47 DAS). In contrast, foliar spray of SA @ 1000 ppm took minimum days for pod formation (41.67 DAS).

Days to physiological maturity is an important phenological stage in which seeding density increases that intrinsically improves the crop yield. A significant effect was observed for seed formation among the various treatments. Physiological maturity is the phenological stage in which accumulation of dry matter in the kernels or seeds ceases, in short- grain filling stops. The days to physiological maturity ranged between 59.67 DAS and 62.67 DAS. Foliar spray of Thiourea @ 500 ppm took maximum days for physiological maturity (62.67 DAS) followed by foliar spray of Thiourea @ 1500 ppm and foliar spray of SA @ 250 ppm (61 DAS). In contrast, foliar spray of SA @ 500 ppm took minimum days for physiological maturity (59.67 DAS). Zubair *et al.* (2007) concluded that correlation results revealed that days to pod initiation had significant positive association with days to maturity, pod length and harvest index.

Seed quality traits

Table 2 : Effect of plant growth regulators on seed quality parameters in mungbean crop.

Treatments	Seed recovery percentage (%)	Seedling length (cm)	Seedling dry weight (mg)	Seed germination (%)	Seed vigour index I	Seed vigour index II
(Control)	73.47	22.46	12.89	39.00	289.51	502.71
Th @ 250 ppm	89.79	34.14	24.00	87.83	819.36	2107.92
Th @ 500 ppm	83.87	33.61	20.78	83.87	698.42	1742.82
Th @ 1000 ppm	87.55	33.09	23.00	59.79	761.07	1375.17
Th @ 1500 ppm	83.76	33.21	21.33	35.33	708.37	753.59
SA @ 250 ppm	75.86	22.64	13.56	39.76	307.00	539.15
SA @ 500 ppm	82.98	32.41	21.67	79.00	702.32	1711.93
SA @ 1000 ppm	85.64	32.28	21.89	83.43	706.61	1826.28
Mean	82.87	30.48	19.89	63.50	624.08	1319.95
S.Em	13.9156	0.6004	0.3685	6.2259	205.4175	132.3507
CD	NS	NS	NS	NS	NS	NS

The seed represents the most critical and valuable input in agriculture and quality seed is the most important attribute for optimum production. Because of the shrinking land resources and global climate change, quality seed assumes paramount importance. Seed processing is the most important component of quality seed production in the achievement of prescribed physical seed standards and is therefore recognized as an important and integral part of the seed production system. Seed size is one of the important yield components which have an effective role in cultivar adaptation to different cultivation which is affecting the seed vigour (Morrison and Xue 2007). The seed recovery percentage ranged between 73.47 and 89.79%. Foliar spray of thiourea @250 ppm exhibited maximum seed recovery percentage (89.79%) i.e., 22.21% over control followed by foliar spray of thiourea @1000 ppm (87.55%). In contrast, foliar spray of SA @250 ppm) exhibited minimum seed recovery percentage (73.47%). Higher seed recovery percentage is attributed to foliar spray of thiourea which is a cytokinin analogue and hence it enhances source activity through increasing cell division, chloroplast development, and maturation. This results in better quality of seed production due to proper assimilate partitioning.

Seed vigour is an important index of seed quality that determines the potential for rapid and uniform emergence of plants (Wen *et al.,* 2018). The seedling stage is affected by seed weight and seed nutrient content, enhanced by priming with bioregulators. The seed vigour index-I ranged between 289.51 and 819.36. Foliar spray of thiourea @250 ppm exhibited maximum seed vigour index-I (819.36) i.e., 183.01% over control followed by foliar spray of thiourea @1000 ppm) (761.07). In contrast, the untreated plot exhibited minimum seed vigour index-I (289.51). Our result is consistent with Jadhav *et al.* (2019) who reported that foliar application of Thiourea @ 500 ppm resulted in seed vigour index-I as 2125 in urban. The vigour index improvement is due to increased germination percentage and seedling length by seed priming treatments in mungbean (Garg *et al.,* 2018). Starch metabolism is of great importance during seed metabolism, which influences seedling vigour. This metabolism is brought about by α-amylases, which hydrolyse the starch reserves into metabolizable sugars providing energy to the developing embryo.

Seed vigour index is an important characteristic of any seed that determines its ability to germinate into an entire plant. Higher vigour index might be due to the efficient protein synthesis and better source to sink relationship which resulted in better development of seeds (Kumar *et al.* 2004). The seed vigour index-II ranged between 502.71 and 2107.92. Foliar spray of thiourea @250 ppm exhibited maximum seed vigour index-II (2107.92) i.e., 319.31 % over control followed by foliar spray of SA @1000 ppm (1826.28). In contrast, foliar spray of thiourea @1500 ppm exhibited minimum seed vigour index-II (502.71). Jadhav *et al.* (2019) also reported that foliar application of Thiourea @ 500 ppm resulted in seed vigour index-II of 459 in urdbean.

Germination and seedling emergence are the critical stages in the plant life cycle, affecting crop yield both quantitatively and qualitatively. This might be due to the resultant effect of seed priming on increased α-amylase activity, which enhances germination. Increased metabolic activities and replication in root tips might have resulted in early and synchronized germination (Basra *et al.,* 2002). The seed germination % ranged between 39.00 and 87.83. Foliar spray of thiourea @250 ppm exhibited maximum seed germination (87.83) i.e., 125.2 % in seed germination over control followed by Foliar spray of thiourea @500 ppm (83.87). In contrast, treatment untreated) exhibited minimum seed germination (39.00). Jadhav *et al.* (2019) also reported that foliar application of Thiourea @ 500 ppm resulted in 85.05 % germination in urdbean.

Seedling length and seedling dry weight are the two important key components that influence seedling growth. The seedling length ranged between 22.46 and 34.14 whereas, seedling dry weight ranged between 12.89 and 24.00. The foliar application of Thiourea @ 250 ppm was found to be superior for both seedling length and seedling dry weight. Thiourea @ 250 ppm exhibited enhancement of 52% in seedling length and 86.19% in seedling dry weight over control. Garg *et al.* (2017) also reported that seedling length ranged between 27.00-51.00 cm and seedling dry weight ranged between 0.01-0.03 mg among various genotypes of mungbean.

Conclusion

Foliar application of Thiourea @250 ppm was found to be the best among all the treatments hence, it is recommended to mung bean growing farmers for better growth, development and enhanced seed quality under Kharif sowing. This will help mungbean to escape stressful conditions and maintain growth and vigour.

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