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Review Article

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Induction of Dormancy in Mungbean - A Review

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ABSTRACT

The germination phenomenon of physiologically mature grains in the pod, usually under wet conditions just before harvest, is termed as pre-harvest sprouting (PHS). Pre harvest sprouting occurs in field crops such as cereals as well as pulses in most region of the world. The non-dormant character is undesirable for mung bean cultivation in summer season where at harvest stage of the crop rains are invariably received and cause heavy losses of produce by way of sprouting of pods in the field. It is more problematic in soil areas where moisture retention capacity is high. A loss of 50-70 per cent in mungbean yield has been reported due to in situ germination. The search for investigation of non-conventional methods of inducing dormancy in mung bean to save the produce and to retain the seed quality against the field sprouting are of greater importance. Seed availability is also reduced because of field sprouting. The research on these aspects of induction of dormancy in mung bean to avoid losses during rainy season has been reviewed in this article.

Key words: *Mung bean, Pre harvest sprouting, Seed dormancy. Dormancy inducing chemicals*

INTRODUCTION

Mung bean (*Vigna radiataL.*) is one of the thirteen different food grain legumes grown in India as one of the major rainy season crops. It is an excellent source of high quality proteins for vegetarians and also in the poor man's diet in the developing countries. Mungbean is cultivated over an area of 2839.7 ha, producing 1,259.5 tonne of grain with an average productivity of 7,774 kg/hec (Anonymous 2014-15). Mungbean [*Vigna radiate* (L.) Wilczek] is one of the important grain legumes of global economic importance. In India, it is the third most important pulse crop after chickpea and pigeon pea. It belongs to family Fabaceae (syn. Leguminoseae) and sub family Papilionaceae. It is believed to have been domesticated from *V. radiata* var. *sublobata*. Mungbean, also known as green gram, has originated in Indian sub-continent. Bihar is considered as secondary centre of diversity.

Mungbeans are mainly cultivated in India, China, Thailand, Philippines, Indonesia, Burma, and Bangladesh and in hot and dry regions of South Europe and Southern USA [52].

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In India, mungbean is widely cultivated throughout the plains and also in hills up to an elevation of 1820 m. It is mainly grown in the states of Maharastra, Andra Pradesh, Rajasthan, Orissa, Karnataka, Bihar, Madhya Pradesh and Uttar Pradesh. Mungbean requires hot and dry climate. Cloudy weather, continuous and heavy rains adversely affect the flowering and poding in mungbean, causing low yields. Mungbean can be grown on well-drained loamy sand to sandy loam soils. The crop is sensitive to alkaline, saline or waterlogged soil. Being a short duration crop, mungbean is cultivated in all three seasons (kharif, rabi and zaid) in different parts of country as a pure crop as well as an associate crop in various cropping systems. Among the three seasons, kharif and zaid is most important and in this season pre-harvest sprouting is a big problem causing huge losses in production. Nearly 60-70% of yield losses have been reported in green gram and black gram due to pre-harvest sprouting[11]**.** The pre-harvest sprouting is sometimes referred to as weather damage. Weather damage is a general term used to describe a range of adverse physical and chemical changes that occur in seed following its exposure to rainfall and humidity. In view of the substantial losses caused by pre-harvest sprouting, it is imperative to develop pre-harvest sprouting tolerant varieties ora need to identify sources of short duration with certain period of dormancy to minimize yield losses due to in situ germination[6,46].

However, the information on pre-harvest sprouting is lacking because little work has been done on this aspect of the crop. Dormancy is an important factor in commercial groundnut production. It can be beneficial when dormancy prevents mature seeds from sprouting before harvest. It can be detrimental when dormancy reduces stand or hampers taking a second crop immediately after harvest. Lack of dormancy in mung bean has been described as an inherent property of seed and does not primarily depend on soil conditions.

The search for investigation of non-conventional methods of inducing dormancy in mung bean to save the produce and to retain the seed quality against the field sprouting are of greater importance. For inducing seed dormancy in Mung bean number of methods have been developed. Foliar application of maleic hydrazide at different stages of crop growth has been successfully used to control sprouting. The key idea in the use of growth regulators is to control some aspects of growth, regulate the balance between source and sink, which is the final analysis results in the higher yield of desired product.

Factor influencing seed dormancy in mungbean:

Seed dormancy in mungbean is controlled by many features. Different causes of seed dormancy in pulses have been reported by many workers. Itis fairly obvious that more than one cause might be responsible for the dormancy of a seed. In a broad view, two types of dormancy can be distinguished *i.e.* (1) "Innate' dormancy where the seeds will not germinate even under favourable conditions and (2) Imposed dormancy where seeds will not germinate when conditions are unfavorable.

Several forms of innate dormancy have been recognized. Seeds may fail to germinate because of impermeable seed coat to water[33]. Rolston[48] Tran and Cavanagh (1984) explained that Hard seededness is the reason for seed coat imposed dormancy or physical in a number of families. It is biologically beneficial for long term seed survival and can be important for wild plants. Hard seededness in soybean is usefull to protect against seed decay and improve agronomic qualities under certain condition[48]. Impermeable Lush and Evans[31] in soybean and Saio[55], Arechavaleta Medina and Snyder[5] studied to understand hard seedness, a comparison of hard and normal seeds is necessary micropyle and raphe must be closed to water, while in permeable seeds these regions may be the initial sites of water entry, but published results on this point are variable. The mechanism, which restricts water uptake and found genotypes that absorb water slowly and factors associated with low water absorption was studied by Eduardo Calero *et* *al.*[9]. They observed seed coat characteristics such as pore numbers, pore shape and distribution of waxy material on selected soybean seed sources with the aid of scanning electron microscope and concluded that small elongated pores and high density of waxy material embedded in the epidermis were associated with low absorption.

Presence of inhibitors and ratio between growth promoters to inhibitor: In recent years the presence of naturally occurring growth inhibitors have received increased attention which is supposed to play an important role in induction and termination of dormancy. Amen[3] has developed a general model for seed dormancy based on the assumption that the state of dormancy is determined by the balance between growth inhibitors and growth promoters. Nagarjun and Gopalkrishnan[37] reported that non-dormant seeds of TMV-2 groundnut contained a water soluble growth promoting hormone and the seed extract induced root initiation in the dormant seeds of TMV-3 groundnut. The physiological studies done by Sreeramulu and Rao[54] revealed that the water soluble hormone was indole acetic acid which has root inducing activity. This auxin was noticed at high levels in the embryonic axis and seed coat of non-dormant seed.

The α-amylase activity of water soaked dormant seeds of rice was very low. The high level of IAA in the embryo was responsible for dormancy. Reduction in IAA levels by high activity of oxidases with available oxygen; GA increased the germination by increasing the-amylase activity[25].

Changes in protein fractions of seeds

Qualitative and quantitative changes

Protein synthesis appears to be obligatory for seed germination in most, if not all species. But it is still not clear whether the regulation of gene expression is involved in the maintenance or break of seed dormancy. It has been hypothesized that dormancy may be controlled by blocking or unblocking the synthesis of particular proteins involved in specific function.

Esahi and Satoh[14] studied the transition of the seeds from a dormant to a non dormant state in Echinocloa crussgalli was associated with the sysnthesis of specific new proteins in the intracellular membrane. The synthesis of a 23 KDa protein was strongly increased upon release of dormancy.

Protein fractions

The germination potential is generally higher in seeds with protein content due to higher energy levels. Murthy *et al.*[35] and Henry *et al.*[19] investigated that the proteins like albumins and globulins were functionally related to seed germination and might also contain oxidative enzymes such as polyphenol oxidase and peroxidase which were also involved in quality parameter.

The majority of albumin globumin proteins were alpha amylase inhibitors and these fractions were important in the breakdown of the starch and their respective amount might have a role in pre harvest sprouting damage of cereals grains such as wheat and shorghum**.** In a comprehensive report on the electrophoretic banding pattern of total seed proteins of mungbean, the presence of 23 polypeptides bands, with molecular weight in the range 17.4 -75.0 K, distributed over 5 zones were observed. Banding pattern analysis showed polymorphism for the presence of a 62.4KD band or 2 band with molecular weight of 61.0 and 58.2KD. Another band, 30.2KD had a high molecular weight variant of 31.3 KD when the total seed proteins of 37 mungbean cultivars were subjected to SDS-polycrylamide gel electrophoresis[39].

Genetic aspects of dormancy:

Dormancy, the physiological phases in seed, is initially determined by the genetic make up of the seed and varies largely among species and even within a species. The variation may be expressed in the strain which is used for the improvement of varieties. Hull[18] reported that dormancy in groundnut is an inherited character and the rest period extended even upto two years in some varieties. John *et al.*[23] pointed out that dormancy is an inherent property of Virginia groundnut. The trait dormancy was found to be partially dominant over the trait nondormancy. Genetic differences in seed dormancy between strains with different botanical groups have been demonstrated for several investigators[30]**.** Yaw *et al*.[1]reported that the seed dormancy is controlled by monogenic inheritance with dominant over non-dormant.

Factor that contribute to resistance to pre harvest sprouting

Among the some specific traits contributing resistance to pre harvest sprouting in hard seeded genotypes. Hard seeded is one of the approaches to solve the problems of pre harvest sprouting in green gram[12,20] hot dry weather tends to increase the proportion of hard seeds and thus improves resistance to pre harvest sprouting and quality for storage[48]. The avoidance of pre harvest sprouting also contributes to reduction of pre harvest losses. Selection for synchronous maturity has been effective in mungbean, as it reduce the vulnerability in the field[45].

Hardness or impermeability of seed coat is said to be one of the many causes for dormancy. This causes physical restriction to the exchange of gas and water which are essential for the initiation of germination process.

The inheritance of hard seed coat varies among and within the species. This dormancy is also mediated by environment prevailing during seed ripening period. Significant morphological differences in the testa among the different cultivars of groundnut were reported. The seeds of 'starr' variety showed relatively thin compact testa while that of Virginia type is thicker[16]**.**

An inhibitory effect of substance within the soybean pod on water imbibitions by the seed was observed by Krul[29]**.** Selection for thick and dence pod walls in soybean was recommended by Tekrony *et al.*[57]. The presence of pubescence on the pod was also associated with slower water uptake by seed in soyabean resulting less pre harvest sprouting[13]. Similar results on resistance to pre harvest sprouting due to thick pod wall, higher podwall weight to surface area and hard seededness in mungbean were also reported by Naidu *et al*[40].

The other pod characteristics imparting resistance to pre-harvest sprouting such as beak length of pod, beak angle, pod wall thickness, rate of water imbibition through pod wall have been reported Satyanarayana *et al*[51]. Naidu *et al*.[40] through association analysis reported that pod beak length had a positive and significant correlation with pod surface area and amount of water absorption indicating the desirability with pod beak.

Legume pods could also contribute some protection against weather damage and pre harvest sprouting. William *et al.*[63] revealed that the lines which were resistant to pre harvest sprouting had thick podwall with the presence of epicuticular wax. They may form as indices for screening of pre harvest sprouting in mungbean.

Chemicals for inducing dormancy:

Barrie *et al.*[7] reported a large number of coumarin derivatives and a few isocoumarines have capacity to induce light sensitive dormancy in seeds of *Lactuca sativa* L.

Jangaard *et al.*[21] reported the high concentrations of salicylic acid and eugenol inhibited the sprouting of nut sedge tubers.

Shibakusha[24] reported synthetic salicylic acid @ 500 ppm inhibit the growth of *Avena sativa* and salicylic acid present in abies sachal inesis mainly responsible for seed dormancy.

Sreeramula[53] studied seed of dormant groundnut cv. TMV-3 during storage at 0, 10, 20, 30 and 40 days after harvest. Dormancy ended at 30 days after storage. In both cotyledons and emrgyonic axis, inhibitory phenolic acid decreased and the synergistic on increased.

Oblidalova[44] studied the excised embryos of barely. He reported that state of dormancy was stimulated by addition of solution containing 1.0 mg coumarin, 0.1 mg chlorogenic acid, 10 mg chloromequat, 1.0 mg ABA and 10 mg cinnamic acid.

Thakur[56] isolated the phenolic growth inhibiting substances from dormant buds of sugarmaple by paper chromatography of their aqueous methanolic extract. An inhibition was

attributed by four major phenolics identified as fearulic, vanillic, coumarin and cinnamic acid.
Khan[27] found abscisic acid involved in the inhibition of the embryo growth rather than in the initiation of germination.

Naqvi and Hanson[41] studied bioassays of aqueocy extracts of guayule, lettuce and tomato seed. He reported that phenolic acid responsible for dormancy in guayule.
Williams and Hougland[62] revealed exogenous application of phenols (10-3 M) to crop and weed seeds substantially delays germination.
Khan and Ungar[27] reported presence of endogenous inhibitors like salicylic acid, syringic and chlorogenic acid in small seeds, could account for germination inhibition in these seeds. He reported that inhibition of germination can be done by exogenous applications of all highly active phenols at 10-2 M concentration.

Farooqi *et al.*[15] reported P coumaric acid, cinnamic acid and small amount of salicylic acid were responsible for rhizome dormancy in *Coctu speciosus*.
Mohanti and Sahoo[34] reported coumarin (90-1350 ppm) gradually decreased the seed germination in rice, ragi, bajara, sesame and *B. juncea*.

Mallik *et al.*[32] reported the presence of growth inhibitor substances in lettuce seed. They evidenced the aqueous extract inhibited the germination and growth of radish and wheat seeds, attributing the activity to the presence of phenols.

Cutillo *et al.*[10] reported the cinnamic acid amides isolated from chenopodium album delayed the germination of *Lactuca sativa* L., *Lycopersion esculentum* L. and *Allium cepa* L. seeds. 50 per cent inhibition was observed at 10 mg/ml concentration.

Williams and Robert[61] observed coumarin is a compound that inhibits seed germination and seedling growth of radish. The greatest inhibitory effect was observed at 10-3 M concentration.

Jaykumar and Manikandan[52] reported the aqueous leaf extract of *Acacia leucopholea* showed inhibitory effects on seed germination, shoot length, root length and leaf area and yield of *Arachis hypogaea* (groundnut) and sorghum due to presence of different phenolic acids *viz.*, hydoguinone,salicylic acid, trans cinnamic acid etc.

Rajjou *et al.*[47] studied the influence of salicylic acid onelicitation of defense mechanism in arbidopsis(*Arbidopsis thaliana*). They also reported that the salicylic acid inhibits the germination of arbidopsis seed and increase the water stress resistance.

Abenavoli *et al.*[1] reported at concentration above 200 mM, coumarin inhibited seedgermination in a concentration dependent manner in duram wheat. Inhibition occurred early during seed imbibition (Phase-I) was rapid and irreversible. During phase-I coumarin inhibited water uptake, electrolyte retention capacity and O2 consumption.
Maleic hydrazide for inducing dormancy: Maleic hydrazide (diethanolamine salt of 1, 2-dihydroxy-3, 6 pyridazine-dione), a growth inhibitor has been successfully used to induce dormancy and thus to reduce sprouting losses in potato, sugarbeat, onion,carrot and rice.
Schoene and Hoffmann[50] reported the growth inhibiting and herbicidalproperties of maleic hydrazide.

The effectiveness of Maleic hydrazide in preventing sprouting of potato tuber was first reported by Zukel[61]**,** Naylor and Davis[43] found that MH was uniformly effective as a growth inhibitor both for dicotyledonous and monocotyledonous plants.

Vaithialingam and Rao[59] reported that induction of dormancy in TMV-2 bunch groundnut by the foliar application of Maleic hydrazide -30, in a field trial conducted at Coimbatore.
Nagarjun and Radder[36] reported that foliar application of Maleic hydrazide could induce dormancy in bunch type of groundnut variety in the field trials.

Gupta *et al*.[17] reported that induction of dormancy in bunch type of groundnut variety T-64 by the foliar spray of Maleic hydrazide in the field trials conducted at Allahabad.

Appalanavidu and Murthy[4] reported that the maleic hydrazide (MH) was found to be successful in inducing dormancy in tubers, bulbs and seeds. Maleic hydrazide concentrations for inductionof seed dormancy: The concentration of Maleic hydrazide is important in obtaining the higher degree of dormancy.

Krishnamurthy[28] conducted the pot culture experiment and revealed that foliar spray of 500 ppm Maleic hydrazide at 15 and 25 days prior to harvest induced dormancy in two varieties of bunch groundnut (Spanish improved and TMV- 2). The number of sprouts reduced from 13.3 to 1.8 in Spanish improved and 17.5 to 5.8 in TMV-2. In a field trial he observed the induction of dormancy in Spanish improved with 200, 400 and 600 ppm concentrations of Maleic hydrazide sprayed at 75, 81 and 106 days after sowing. Sprouting was 10.3, 12.7 and 10.5 per cent due to 200, 400 and 600 ppm concentrations respectively as compared to that of unsprayed control (25.6 %). Vaithialingam and Rao[60] reported that the Maleic hydrazide sprayed @ 5000 ppm at 70 DAS, 15000 ppm at 80 DAS and 10,000 ppm at 90 DAS induced dormancy ranging from 30 to 40 per cent.

Vaithialingam and Rao[59] reported that the Maleic hydrazide -30 application as foliar spray was done at 0, 5000, 10000, 15000, 20000, 25000 and 30000 ppm at 70, 80 and 90 DAS. Revealed that irrespective of stages of application, all the treatments reduced the germination of the non-dormant seeds severely and increased the total free amino acid content while inducing dormancy.

Nagarjun *et al*.[38] conducted a field trial with bunch groundnut to study the optimum stage and concentrations of Maleic hydrazide for foliar spray on the seed quantity and subsequent growth of seedlings. They reported that there was a reduction in seed moisture content due to foliar spray of 250 ppm Maleic hydrazide in the early stage of crop growth (60 days). However, the MH application did not show any effect on seed purity, seed viability and seed protein content and seedling growth, while Maleic hydrazide at concentrations greater than 500 ppm increased oil content significantly. Nagarjun and Radder[36] observed that foliar spray of maleic hydrazide (MH) after 60 days of sowing was found to be superior in inducing seed dormancy compared to later stages of Maleic hydrazide application (75 and 90 days of crop growth). The concentrations ranging from 250 to 1000 ppm remarkably enhanced the seed dormancy to the extent of 60-80 per cent.

However, application of Maleic hydrazide in lower concentrations (250 ppm) at an early stage of crop growth (60 days) was found to be as good as that of higher concentrations in inducing seed dormancy.

Reduction in moisture content and the rate of catalase enzyme activity were in association with increase in the degree of induced seed dormancy.

Gupta *et al*.[17] have reported that a foliar spray of MH @ 15 x 103 or 20 x 103 ppm applied to groundnut variety (T-64) at 90 days after sowing induced the seed dormancy.

Bhapkar *et al*.[8] revealed that a foliar application of Maleic hydrazide -30 at different concentrations *viz*., 5000 ppm at 70 DAS, 10000 ppm at 90 DAS induced seed dormancy ranging from 30 to 40 per cent.

Abrar and Jadhav[2] reported that the seed dormancy period was increased from 5 to 25 days in cv. PI-139915 and PI-169292 by 200 ppm MH applied as foliar spray one month before harvesting.

Jagatap[18] studied the induction of seed dormancy in bunchy groundnut genotypes *viz*., RHRG-12, TAG-24, RHRG-16 and SB-XI. He revealed that seed dormancy could be induced upto 30, 10, 30 and 20 days, respectively by foliar application of Maleic hydrazide @ 250 ppm than other concentrations of Maleic hydrazide applied *viz*.,500 and 750 ppm.The seed viability remains unaffected due to Maleic hydrazide spray @ 250,500, 750 ppm in all the genotypes.

Nautiyal[42] revealed that foliar spray of malic hydrazide @ 1000 ppm at 60 days after crop emergence was found to be superior in inducing dormancy in Spanish groundnut cultivars. A reduction in the moisture content of the seed also indicates that the application of MH prevented the pods to absorb moisture even through there was plenty of moisture in the surrounding soil atmosphere during pod development**.** Foliar application of ccc (500ppm) and maleic hydrazide 100ppm at 45,50,55 and 60 days after sowing on seed quality and pre harvest sprouting in mung bean were studied. The foliar application of plant growth regulators significantly enhanced growth, yield and seed quality. The application of plant growth regulators at the advanced growth stages was more effective in the improvement of seed quality parameters by Suryawanshi, Mate, Deshmukh, Bharud.

CONCLUSION

Application of maleic hydrazide at different stages of crop growth has the capability of altering the seed dormancy. The foliar application of Maleic hydrazide a growth inhibitor can be successfully used as a source of short duration of dormancy to minimize yield losses due to in situ germination by application of proper concentrations of maleic hydrazide and its time of application on the locally available mung besn. Similarly the review also made available various dormant and non dormant genotypes to use in breeding programme. This review will help to conduct further studies in dormancy of mung bean.

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