A DISSERTATION REPORT ON

Studies on effect of herbicides at crop maturity stage to avoid weed interference during harvest and seed quality in soybean (*Glycine max* (L.) Merrill)

By

Mukul Rathore

A Thesis

Submitted to Institute of Agriculture Science (Seed Technology)

Bundelkhand University, Jhansi (U.P)

A partial fulfillment of the requirement for the

Award of the degree in

MASTER OF SCIENCE
In
SEED TECHNOLOGY
Year 2022-23

Under the esteemed Guidance of
Dr. M.K. Kuchlan
Senior Scientist, IISR
Indore

Co- guided by
Dr. Punam Kuchlan
ICAR-IISR, Indore

ICAR-INDIAN INSTITUTE OF SOYBEAN RESEARCH
INDORE - 452001 (M.P.)

ICAR-Indian Institute of Soybean Research
Khandwa Road, Indore-452001

Dr. Mrinal K. Kuchlan
Senior Scientist
Division of Corp Improvement
ICAR-IISR, Indore MP, India

CERTIFICATE

It is certified that dissertation report entitled "**Studies on effect of herbicides at crop maturity stage to avoid weed interference during harvest and seed quality in soybean (*Glycine max* (L.) Merrill)**" which is being submitted by **Mr. Mukul Rathore** in partial fulfillment of the degree of **MASTER OF SCIENCE** in **Seed Technology** of **Bundelkhand University, Jhansi** is a record of candidate's own work carried out by him under my supervision and guidance. The matter embodied in this report has not been submitted by him for any other degree.

Dr. Mrinal K. Kuchlan
Senior Scientist
ICAR-IISR, Indore

BUNDELKHAND UNIVERSITY, JHANSI

EVALUATION CERTIFICATE

This is to certify that the work embodied in the dissertation entitled, "**Studies on effect of herbicides at crop maturity stage to avoid weed interference during harvest and seed quality in soybean (*Glycine max* (L.) Merrill)"** submitted for the partial fulfillment for the award of degree of **Master of Science (Agriculture) in Seed Technology, Institute of Agriculture Sciences, Bundelkhand University, Jhansi-284128**, by **Mr. Mukul Rathore, M.Sc. (Ag.) Seed Technology,** Roll No. **- 211165091006** and Enrolment No. - **BU0210307199** was duly examined and found satisfactory for the award of master degree in Agriculture (**Seed Technology**) to **Mr. Mukul Rathore**

Name	Designation	Signature
1. Dr. Mrinal K. Kuchlan	**Chairperson**	----------
2. Dr. Punam Kuchlan	**Co-Chairperson**	----------
3. ----------	**External Examiner**	----------
4. Prof. B. Gangwar	**Professor & Head**	----------

BUNDELKHAND UNIVERSITY, JHANSI

BONAFIDE CERTIFICATE

This is to certify that the dissertation "**Studies on effect of herbicides at crop maturity stage to avoid weed interference during harvest and seed quality in soybean (*Glycine max* (L.) Merrill)"** is a bonafide record of independent work done by **Mr. Mukul Rathore**, under the supervision of **Dr. Mrinal K. Kuchlan** submitted to Institute of Agriculture Science, Bundelkhand University, in partial fulfillment for the award of the degree of Master of Science (Agriculture) in Seed Technology. The work embodied in this dissertation has not been submitted to any other University or Institution for the award of any degree.

Dr. Ashok Kumar
Head,
Department of Seed Technology
Bundelkhand University,
Jhansi (U.P.)

DECLARATION

I **Mukul Rathore**, hereby declare that the project report entitled **"Studies on effect of herbicides at crop maturity stage to avoid weed interference during harvest and seed quality in soybean (*Glycine max* (L.) Merrill)"** is submitted by me for the partial fulfillment of the requirement for the award of **Master of Science** in **Seed Technology** to the Institute of Agricultural Science, Bundelkhand University, Jhansi, comprises my own work and due acknowledgement has been made in text to all other material used.

Place: Indore / Jhansi
Date:

Mukul Rathore

ACKNOWLEDGEMENTS

Behind every success, there is certainly an unseen power of almighty, God but an aim is the internal condition of success which is attainable at perfection in everything by who preserve with the association of their predecessor, teachers, family members, friends, and colleagues. Word seems hopelessly inadequate and a limitation of my diction stands quite prominent in the context of magnitude of my feeling.

It is my proudest privilege to express deepest sense of reverence and heartfelt thanks to my project guide ***Dr. Mrinal K. Kuchlan*** *Senior scientist at Indian Institute of soybean Research Indore, M.P., for his noble guidance, valuable suggestions excellent counsel throughout the investigation and preparation of the manuscript. It is a great pleasure to work under such a great personality.*

I wish to express my deep sense of gratitude to Co- Guide ***Dr. Punam Kuchlan*** *for her able guidance and useful suggestions, which helped me in completing the project work, in time.*

I would also thank ***Prof. B. Gangwar*** *Professor and Head of the Department to Institute of Agricultural Science, Bundelkhand University, Jhansi for their selfless help and guidance during the whole master degree.*

I would be grateful to Mr. Ajay Patel (SRF), Mr. Ravi Pandey (SRF), Mr. Rajesh Patel (YP), and Samiksha Hote (YP) for their continuous support and help during my entire work at seed technology laboratory at Indian Institute of Soybean Research Indore.

Finally, yet importantly, I would like to express my heartfelt thanks to my beloved parents for their blessings, my friends specially classmates, training batch mates, Vishal Nayak, Yash Soni, and Kapil Anjana for their help and wishes for the successful completion of this project.

Many more people helped me, if I do not list them all; it is not for lack of gratitude but for lack of space. To them, I give my heartiest thanks.

LIST OF CONTENTS

LIST OF TABLES

LIST OF PLATES

INTRODUCTION

The most significant seed legume in the world is the soybean (*Glycine max* (L.) Merrill), which produces 25% of the world's edible oil and almost two-thirds of the protein concentrate used in livestock feed. Soybean cultivation and consumption can be dated to the start of China's agrarian era. For generations, soybean has been associated with meat, milk, cheese, bread, and oil by the people of China, Japan, Korea, Manchuria, the Philippines, and Indonesia. This may be the cause of it earning the nicknames "Cow of the Field" or "Gold from Soil" in these nations. Soybean seeds have been used for many years to make a range of fresh, fermented, and dried food varieties in Asia and other regions of the world (Probst and Judd, 1973). The protein in soybeans is referred to as a complete protein because of its amino acid content. Its nutritional value for preventing diabetes and heart disease is widely recognised. The "Big-3" producers of the modern era are the United States, Brazil, and Argentina. Soybean was first introduced to India in the tenth century AD via the Himalayan routes and by Indonesian traders via Burma (now Myanmar). As a result, small-scale soybean farming has historically been practised in Himachal Pradesh, the Kumaon Hills of Uttar Pradesh (now Uttaranchal), eastern Bengal, the Khasi Hills, Manipur, the Naga Hills, and regions of central India that include Madhya Pradesh. Additionally, it has been reported that, after China, the Indian continent is where the crop was first domesticated. As it is a legume crop, soybean may use atmospheric nitrogen through biological nitrogen fixation, which reduces its demand on manmade nitrogen fertilisers. Given its numerous benefits, there is sufficient justification for its significant participation in important crop development programmes all over the world.

Soybean ranks first, among oilseed crops in the world and India. It is a predominant rainy season crop of the rainfed agroecosystem of India. The area planted with soybeans in India was 12.81 million ha in 2020-21 and production 12.90 million ton with average productivity of 1007kg/ha (Agricultural Statistics at a Glance 2021). Madhya Pradesh and Maharashtra account for 89 percent of all soybean output in India, with the rest of the production being produced in Rajasthan, Karnataka, Chhattisgarh, and Gujarat. In addition to other crops, Madhya Pradesh (The Soy State), which produces the majority of India's soybeans and occupies an area of about 58.54 lakh hectares, is renowned as the "bowl of soybeans"

After reaching physiological maturity, seeds enter a phase of degradation and start to lose their ability to germinate over time. Unfavourable weather during the pre-harvest post-maturation period might lead to mild to serious difficulties with seed quality. Herbicides are thus occasionally used on crops as harvest-aid treatments to speed up seed drying and encourage uniform seed maturity at harvest.

In order to achieve optimal yield, high quality seed is essential for maximizing seed germination and seedling vigour (Hussaini, 2014). In tropical and subtropical areas, a number of factors, including the sowing and harvesting phases, can have adverse effects on soybean seed production and quality. As stated by Kumar *et al*. (2012) the maturity stage of crops has a significant impact on seed yield and quality. Therefore, it is crucial to harvest seeds at the ideal stage of maturation because doing so early on or too late results in poorer yields and lower-quality seeds.

The natural pattern is for soybean prices to rise when there is a shortage on the market. As a result, some farmers use herbicides to accelerate the maturity and desiccation of the soybean crop without paying attention to the seed production and quality. There are different findings about the impact of desiccation on soybean seed production when it comes to the indication of chemical desiccation. When desiccants are applied before the physiological maturity, the yield of soybeans can be decreased (Lamego *et al*. 2013). Desiccation is advised to occur after stage R8 in cultivars with unpredictable growth habits because the pods continue to develop even after reaching physiological maturity (Zagonel,2005). Accordingly, a study was conducted to ascertain the yield and quality of soybean seeds harvested after employing herbicides as a desiccant in terms of size and weight.

The harvest date has a big impact on soybean production and seed quality because of variances in maturity. It is more important than ever to identify or test for the appropriate maturity stage for producing high-quality seeds. To improve and guarantee the quality and viability of soybean seed, it is essential to ascertain the proper maturation stage period.

Keeping above facts in view, the present investigation has been proposed with the following objectives:

1.To study the effect of herbicides on seed quality.

2.To study the effect of herbicides at crop maturity stage.

REVIEW OF LITERATURE

Slife (1956) reported that 2,4-D and 2,4,5-T reduced soybean yields about equally. Silvex applied at the bloom stage was the only herbicide that reduced germination and it only by 5 %.

Slife (1956) found that 2,4-D reduced germination of seeds produced by treated plants.

Slife (1956) concluded that Seed yields were not affected by 1/161 or 1i8 lb/A of 2,4-D acid in the amine form when applied to soybeans 3 to 5 inches tall and 7 to 9 inches tall. The yields were affected slightly at the same rates when soybeans were sprayed at 18 to 20 inches tall. The 14 and 1/2 lb/A rates of 2, 4-D affected yields at all stages but were less severe when applied at 3 to 5 inches tall.

Schultz (1967) observed that in corn (*Zea mays* 1.), soybean (*Glycine max* 1.) grain sorghum (Sorghum bicolor) and cucumber seed germination was not inhibited when they were treated with trifulralin in laboratory. The same response was noted for cotton (Gossypium hirsutum) by Hassawy and Hamilton (1971). Since the germination processes are not directly inhibited by the dinitroaniline herbicides, so the toxic effect must take place between the time of radicle and shoot emergence of seedlings from the soil. This very conclusion was given by Fayte *et al*. (1982). Kolhe *et al*. (1984) also found that butachlor, penditnethalin and thiobencarb did not inhibit germination of rice seeds but toxicity due to herbicide appeared after germination.

Wax *et al.* (1969) found that the 2,4-D treatments at either stage of growth and the dicamba and picloram treatments at the pre-bloom stage had little effect on germination of the harvested seed. In contrast, the higher rates of dicamba and picloram applied at the bloom stage markedly reduced germination percentage.

Caviness and Johnson (1971) reported that spraying of Paraquat at the rate of 0.37 lb/acre 25 days before maturity reduced oil, protein content and deteriorated the seed quality.

Klingman and Murray and (1976) found that there was no effect or only minimal effect on germination and seedling development from the glyphosate herbicide treatment. However, paraquat when used under such extreme conditions greatly reduced stands of seedlings.

Baur *et al*. (1977) found that glyphosate reduced seedling survival and increased abnormal seedlings when applied to *Sorghum bicolor* (L.) Moench (sorghum) with 30 to 40% moisture content.

Whigham and Stoller (1979) showed reductions in seedling growth from glyphosate compared with paraquat with little timing effect.

Whigham and Stoller (1979) found that Application of paraquat 3 and 4 week before harvest was effective for desiccation of soybean foliage but reduced soybean yield.

Whigham and Stoller (1979) reported that Glyphosate at 1.7 and 3.4 kg/ha applied 2, 3, or 4 weeks before harvest also reduced soybean seed germination in research.

Eastin (1980) observed a reduction in head rice yield of 2% when sodium chlorate at 5.04 kg/ha was applied at 7 days compared with 3 days pre-harvest.

Azlin and McWhorter (1981) concluded that germination of soybean seed was reduced at 30^0 C only when glyphosate was applied at 2.24 and 3.36 kg/ha 23 to 29 days before harvest, or at 3.36 kg/ha applied 15 to 21 days before harvest. At alternating temperatures (10.6^0 C for 72 h followed by 30^0 C for 72 h), all treatments applied 23 to 29 days before harvest reduced soybean seed germination; glyphosate at 1.12, 1.68, and 3.36 kg/ha applied 15 to 21 days before harvest also reduced germination. Seed from plots treated with glyphosate 23 to 29 or 15 to 21 days before harvest produced atypical soybean plants.

Azlin and McWhorter (1981) found that glyphosate applied more than 2 weeks before full maturity of soybeans could be detrimental to soybean yields and to the quality of soybean seed. Glyphosate applied 7 to 12 days before harvest could be useful in providing future control of perennial weeds without adverse effect on soybean yields and seed quality.

Azlin and McWhorter (1981) reported that Germination was reduced by glyphosate at 1.12 to 3.36 kg/ha when applications were 15 to 21 days before harvest.

Azlin and McWhorter (1981) found that Oil content was reduced when glyphosate was applied at 3.36 kg/ha 23 to 29 days before harvest.

Soplin (1981) revealed that glyphosate consistently reduced seed germination and seedling vigour when sprayed on plants with seed at or near physiological maturity.

Hampton and Hebblethwaite (1982). reported that Glyphosate can be applied preharvest to cereal crops for control of annual and perennial grass and broad-leaved weeds.

Cerkauskas *et al.* (1982) indicated that application of glyphosate at 3.83 kg a.i./ha at stage of beginning maturity caused reduction in seed germination of soybean.

Cerkauskas *et al.* (1982) found that Desiccation of plants by paraquat significantly reduced seed weight and germination at all locations and increased the incidence of Alternaria and Phomopsis spp. at Urbana. Analysis of the combined data from the Brazilian locations showed a significant decrease in seed germination for all treatments except paraquat sprayed on the UFV2 at R7 and sodium chlorate: sodium borate sprayed on UFV1 at R7.

Prakash and Pahwa (1984) found that 1.2 kg methabenzthiazuron or pendimethalin, 0.6 to 1.2 kg diclofopmethyl, 0.5 to 1.0 kg fluchloralin and 0.1 to 0.2 kg oxfluorfen/ha applied as pre-emergence descreased root length but not shot length. Shoot growth inhibition has been reported in various plant species such as in cotton by Oliver and Frans (1965), Stendifer and Thomas (1965), Hess and Bayer (1974), in soybean by Burnside (1971), Kust and Struckmeyer (1971), Swann and Behrans (1972), Swanson (1972). At later stages of growth, the shoot dry weight was increased with 1.0 to 1.5 kg methasenzthiazuron, 0.6 kg diclofomethyl, all rates of fluchloralin, 1.5 to 2.0 kg pendimethalin and 0.1 kg oxyflurofen.

Shad and Chaudhary (1985) found that trifluralin at 0.50 kg/ha and 0.75 kg/ha delay germination by 5 - 7 days as compared to the control in chickpea.

Semidey and Almodovar (1987) found that 1.68 to 6.72 kg/ha Oxyfluorfen used as pre-emergence significantly reduced the germination by 20% in pigeon pea.

Bollich *et al.* (1988) conducted investigation to determine the influence of pendimethalin and trifluralin on soybean. Pendimethalin and trifluralin applied at rates of 1.1, 1.7 and 2.2 kg/ha delayed emergence and injured soybean seedlings. Dry weight also decreased with all rates of herbicide during the vegetative growth stages. Seedlings injury was severe at 1.7 and 2.2 kg/ha for both herbicides.

Pahwa *et al*. (1988) studied the effect of pendimethalin applied to the soil surface @ 1.0, 1.5 and 2.0 kg/ha and fluchloralin @ 0.7, 1.0 and 1.25 kg/ha in pots 2 days after sowing of pigeon pea. The length of main stem and primary root was reduced significantly while fresh

and dry weights of shoots were reduced initially, the fresh and dry weights of roots increased significantly at lower concentrations and decreased at higher herbicide concentrations.

Ratnayake and Shaw (1992) revealed that paraquat and glufosinate reduced seed weight when applied at RS and R6. Glyphosate and AC 263,222 reduced seed germination when applied at RS, R6, and R7 growth stages, and normal seedling percentages were also reduced by glyphosate at these growth stages. Glufosinate and AC 263,222 affected normal seedlings only at R5 and R6. Soybean hypocotyl and primary root lengths were reduced by glyphosate and AC 263,222 applications at R5 and R6, whereas glufosinate and paraquat did not affect these variables. Glyphosate applied at R5 reduced shoot weight in 1 month old soybean plants.

Ratnayake and Shaw (1992) revealed that glufosinate and glyphosate reduced seed weight 12% when applied at R7. Seed weight was not affected by any herbicide applied at the R8 growth stage. Glufosinate and paraquat applied at R7 reduced germination 26 and 22%, respectively, while AC 263,222 and glyphosate reduced germination 11 and 20%, respectively. The herbicides applied at R8 did not affect sicklepod seed germination.

Darwent *et al*. (1994) applications of glyphosate at rates of 0.45, 0.9 and 1.7 kg ai ha^{-1} to wheat resulted in little or no difference in 1000-seed weight, sample density, seed germination and protein content.

Campbell *et al.* (1998) found that Glyphosate also reduce the percentage of mature seedheads but had little impacts on germination of the seeds and no effect on the growth of the seedlings from the seeds.

Zollinger *et al*. (1999) reported that an application of glyphosate prior to the hard dough stage or physiological maturity caused decreases in kernel weight and kernel size.

Bennett and Shaw (2000) found that glyphosate applied prior to plant harvest, especially at earlier maturity stage, inhibits the seed germination, emergence and growth of offspring plants. This effect, however, depends mostly on the development stage at which desiccation is performed and dose of glyphosate.

Yenish and Young (2000) application of glyphosate in three maturity stages of wheat milk stage, soft dough and hard dough stage at the doses of 0.62 and 0.84 kg ha^{-1}.

Wilson and Smith (2002) suggested that dry bean seed weight and seed yield were reduced by all harvest-aid treatments applied when only 5 to 7% of the seedpods were yellow. Herbicides did not affect dry bean seed yield, weight, or germination if treatments were delayed until 77 to 85% of the seedpods had turned yellow.

Baig *et al*. (2003) showed that pre-harvest applications of glyphosate reduced seedling shoot weight of pea.

Blackburn *et al.* (2003) reported that the application of glyphosate at 1%, 10%, or 100% of an 890 g ai ha^{-1} rate to soybean near seed maturity had significant effects on germination and/or growth of the resulting F1 generation.

Manthey *et al*. (2004) studied that effect of pre-harvest application of herbicide, including glyphosate, paraquat and 2,4-D and observed a decrease in 1000-kernel weight (TKW) when glyphosate was applied at the soft dough stage.

Emine *et al*. (2007) conducted experiment in Diyarbakir, Turkey, to study the effect of thidiazoron + diuron application at 40, 50, 60 and 70 % boll opening stage of cotton. They showed no significant difference with respect to ginning percentage, 100 seed weight, seed germination percentage, fiber fineness, fiber length, fiber strength. Which means quality of parameters of cotton were not affected by the treatments.

Demir *et al*. (2008) suggested that stage of maturity at harvest is one of the most important factors that can influence the quality of seeds. Therefore, successful seed production depends on detection and prompt harvesting at appropriate time.

Albrecht *et al.* (2012) found that the decrease on seed germination for herbicide applications in the different development stages (V6 and R2) with the increase in doses of glyphosate.

Mishra *et al.* (2013) reported that application of imazamox at 350 ml/ha as early post-emergence caused more reduction in the density and dry weight of all the dicot weeds. Because it is readily absorbed through the roots and foliage, translocation in the xylem and phloem through the plant and accumulated in growing points.

Jaskulski and Jaskulska (2014) found that glyphosate applied at the dose of 2.0 kg ha^{-1} decreased the thousand grain weight and already at the dose of 1.0 kg ha^{-1} decreased the grain germination energy, length and weight of primary roots.

Mcnaughton *et al.* (2015) suggested that Glyphosate and saflufenacil accumulate in dry edible bean seeds desiccated in preharvest, especially when applied before physiological maturity.

Parmar *et al.* (2017) reported that the seed yield per hectare of soybean was higher under two hand weeding at 20 and 40 DAS (922.22 kg ha^{-1}) followed by imazethapyr + imazamox @ 70g a.i. ha^{-1} (797.22 kg ha^{-1}), quizalofop-ethyl @ 50 g a.i. ha^{-1} fb chlorimuron-ethyl @ 9 g a.i. ha^{-1} (769.44 kg ha^{-1}) and chlorimuron-ethyl @ 9 g a.i. ha^{-1} (741.67 kg ha^{-1}) than pre plant incorporation of glyphosate, pre emergence application of pendimethalin and alachlor and post emergence application of quizalofop-ethyl @ 50 g a.i. ha^{-1} and weedy check (436.11 kg ha^{-1}).Uncontrolled weeds in weedy check resulted yield loss of 52.25% in soybean.

Fipke *et al.* (2018) reported that pre-harvest application of the herbicide glufosinate-ammonium does not affect the physiological quality expressed by the vigour and germination of seeds in the wheat crop.

Fipke *et al.* (2018) found that the application of non-selective herbicides on wheat pre-harvest impairs the physical and physiological quality and promotes faster deterioration.

Perboni *et al.* (2018) found that 2,4-D+glyphosate reduces germination of wheat seeds when applied in the soft dough to hard dough stage.

Rosado *et al.* (2019) found that Application of paraquat molecule at the R8 stage and the paraquat + diuron mixture at the R8/R9 stage reduced the viability and vigour of the bean seeds, and compromised yield.

Scholtes *et al.* (2019) suggested that soybean response to 2,4-D and dicamba can be variable within vegetative or reproductive growth stages; therefore, specific growth stage at the time of exposure should be considered when evaluating injury from off target movement. In addition, application of dicamba near susceptible soybean within the V4 to R2 growth stages should be avoided because this is the time of maximum susceptibility

Malalgoda *et al.* (2020) reported the effect of pre-harvest glyphosate applied at different stages of maturity, namely at the soft dough stage (45% moisture content) and the ripe stage (physiological maturity/30% moisture content and recommended application stage), on different spring wheat quality characteristics, ranging from kernel quality to end-product baking performance.

MATERIAL AND METHODS

The experiment was conducted at ICAR-Indian Institute of soybean research farm, Indore during rainy season (June-October) of 2022 (22.78° N, 75.88° E), India. The experimental site has black (Vertisols) soils with high to moderate depth, high water holding capacity and medium fertility. Recommended dose of fertilizers was applied at the time of planting. Standard agronomic practices for weed and insect control were uniformly followed.

The recommended dose of fertilizer: N:P:K and S is 20:60:40 & 20 kg per hectare. In this experiment N,P,K and S was applied in the form of NPK : 12:32:16 at the rate of 2 quintal per hectare and bentonite Sulphur 20 kg/ha.

In this practice land preparation was done with summer plough using reversible mould board plough following 2 crisscross harrowing or cultivation for breaking soil clods. Harrowing was followed after arrival of monsoon and planking to level the field for proper sowing. In this process the preceding wheat crop stubble are broken and mixed in soil. The wheat stubbles are seen on the field which get decomposed with the onset of monsoon and soil moisture. The wheat stubble if not broken and mixed with soil, cause disturbance in proper sowing. The fertilizers were broadcasted and mixed before sowing while doing harrowing and planking or sowing was followed with ferti-seed drill where fertilizer and seeds were placed side by side at 3inch gap. Soybean genotype NRC130 and NRC 86 was planted in two different field.

Herbicides spray apply at seed crop maturity

S. No.	Treatment	Dose
1	T_1 Imazethapyr 35% + Imazamox 35 % WG	100 g/ha
2	T_2 Glyphosate 41% S.L.	2 L/ha
3	T_3 Paraquat dichloride 24% S.L.	2 L/ha
4	Control	

Seed Index (g)

Hundred seed weight was recorded as per the procedure given by ISTA rules (Anon., 1993). The average weight was recorded in grams.

Seed yield (q/ha)

Seed yield per plot was recorded by taking the weight of the seeds obtained from the net plot after rejecting out the border rows. The seed yield of net plot was expressed in quintal per hectare.

Germination testing

Germination of a seed lot in a laboratory is the emergence and development of the seedling to a stage where the aspect of its essential structures indicates whether or not it is able to develop further into a satisfactory plant under favorable conditions in soil. These essential structures are a well-developed and intact root system, hypocotyl, plumule and one or two cotyledons Seedlings cannot be evaluated in a germination test until these essential structures are clearly identifiable and the reported percentage germination expresses the proportion of seeds which have produced normal seedlings within the period specified for each species.

General Principles

Germination tests shall be made with seeds from the pure seed fraction of a purity test. A minimum of four hundred seeds are required in four replicates of 100 seeds each or eight replicates of 50 seeds each depending on the size of seeds and size of containers of substrate.

General Requirements for Germination.

Seeds require certain conditions for normal germination. The most important requirements are substrata, moisture, temperature and light.

1. Suitable substratum

The substrata serve as a moisture reservoir and provide a surface or medium for which the seeds can germinate and the seedlings grow. The commonly used substrates are paper, sand and soil.

a. Paper substratum

Most widely used paper substrates are filter paper, blotter or towel (kraft paper), these are easy to handle versatile and comparatively cheap.

Specification of Germination paper:

Germination paper should preferably possess a creaped surface. The paper should have an open, porous formation and he free from impurities or toxic substances that may affect seed germination. It should be free of fungi or bacteria which might interfere with the growth or evaluation of seedlings. It should hold sufficient moisture during the period of test and should possess sufficient strength to resist wear and tear during handling. The texture should be such that the roots of germinating seedlings will grow on and not into the paper.

The paper shall meet the following requirements.

Type of Paper	Basis Mass (g/m2)	Bursting Strength(kg/em')	Capillary rise (in mm). Min	PH	Ash, % by mass (Max.)
Filter paper	130-135	1.0	30	6.0 to 7.5	1.20
Towel paper	95-100	2.0	30	6.0 to 7.5	1.50

Biological Test for Toxic Materials:

In this, test, comparison shall be made between germination papers of unknown quality and known acceptable quality. Pieces of paper should be cut to size and placed in petri dishes or plastic boxes. Petri dishes or plastic boxes should be lined with two thickness of such paper. The papers should be saturated with tap water and seeds of Brassica species or onion should be germinated. Evaluation may be done by comparing the development of the seedlings grown on unknown quality of paper and those grown on the known quality of paper. The evaluation of seedlings shall be made after 3 days in case of Brassica and after 6 days in case of onion. If paper of unknown quality contains toxic substances, the root tips will be shortened and sometimes discolored, root hairs bunched and sometimes plumules shortened.

Determination of Capillary Rise

Cut ten strips of paper each 10 mm wide, five in the machine direction of the paper and five in the cross-machine direction. Immense each strip in distilled water at 27 12° C to a depth of 20 mm at the end of the strip. After 2 min measure the height to which the water has risen in the strip, to the nearest 1 mm. Calculate the average of the 5 strips in the cross machine direction. The lower of these two averages shall be taken as the result for the test.

2. Adequate Moisture of Water

High concentration of water at cellular level is necessary for the seed to start germination. Moisture is supplied to the seeds through the substratum. Generally, the moistened substrata is sufficient to rehydrate to 30-80 per cent. However, the moment the radicle emerges, additional moisture contributes better seedling growth. In the case of vegetable seeds, care is necessary in moistening the substrata. Too much water would allow fungal growth and decay of seeds.

The general specifications for water are: It should be free from organic or inorganic impurities. The pH value should be within the range of 6.0 to 7.5. If the usual water supply in the laboratory is not satisfactory, distilled, de-ionized water may be used. To ensure the quality of water being used, an analysis should be obtained from time to time.

3. Favorable Temperature

Seeds of most of agricultural and horticultural crops germinate in the temperature range of 10° C to 35° C Some seeds germinate better at constant temperature Others require an alternating temperature.

Temperature control is also necessary to overcome dormancy wherever it occurs. Exposure of seeds to the temperature at 40° C or higher, alternation of temperature, low temperature applications are the easiest and safest method to overcome seed dormancy although methods to overcome dormancy by chemical treatments do exist.

Therefore, the temperatures prescribed in the above Table should be determined at the level of the seeds on the substrate.

Temperatures should be as uniform as possible throughout the germination apparatus and care should be taken that the temperature of tests does not exceed the level prescribed in the Table and should not be more than ± 1° C.

Where alternating temperatures are indicated, the lower temperature should usually be maintained for 16 hours and the higher for 8 hours. If alternation of temperatures cannot be controlled over week-ends or public holidays, the test should be kept at lower temperature.

4. Light:

There are crops for which light is not required during germination test. However, presence of light is desirable to enable the evaluation of seedlings easier and with greater certainty. Other crops like lettuce and tobacco require light during germination on the test. Seeds of most of the species in the Table will germinate either in light or in darkness. However, illumination of the substrate from artificial source or by day light is generally recommended for better seedling development to avoid etiolation and also to detect seedlings having chlorophyll deficiency.

Specifications for soybean germination testing

Crop	**Media**	**Temperature**	**1st count**	**Final count**	**Addl. directions**
Soybean	BP, S	20-30° C, 25° C	5	8	-

Procedures of germination testing

Working sample

Four hundred seeds are counted at random from the well-mixed pure seed. Replicates of 100 seeds are normally used, spaced sufficiently far apart on the seed bed to minimize the effect of adjacent seeds on seedling development. To ensure adequate spacing, split replicates of 50 or even 25 seeds may be necessary, particularly where there is seed-borne disease.

Testing four hundred seeds is recommended on seed law enforcement, seed certification and service samples.

Methods using paper:

Paper substrates are used for the following methods:

(a) BP (Between paper):

The seeds are germinated between two layers of paper. This may be achieved by loosely covering the seeds with an additional layer of paper or by placing the seeds in rolled towels. The rolled towels are to be placed inside the germinator in an upright position.

Methods using sand

The seeds are planted on a leveled layer of moist sand and covered with 10-20 mm of uncompressed sand depending on the size of the seed. To ensure good aeration it is recommended that the bottom layer of sand be loosened by raking before sowing Sand may be used instead of paper, even if not prescribed in Table when the evaluation of a diseased sample proved impracticable because of the contamination of the paper substrate.

Seedlings Evaluation

Seedling which have reached a stage when all essential structures can be accurately assessed, shall be removed from the test at the first or any other intermediate counts. Badly decayed seedlings should be removed in order to reduce the risk of secondary infection, but abnormal seedlings with other defects should be left on the substrate until the final count.

Categories of seedlings

Normal Seedlings

Normal seedling is one which shows the capacity for continued development into mature plant when grown in good quality soil and under favorable conditions of water supply. temperature and light.

According to the International Seed Testing Association (1985) seedlings to be classified as normal seedling, must conform with one of the following categories:

a) Intact seedlings: Seedlings with all their essential structures, well developed complete in all proportion and healthy.

b) Seedlings with slight defects: Seedlings showing certain slight defects of their essential structures provided they show an otherwise satisfactory and balanced development comparable to that of intact seedlings of the same test

c) Seedlings with secondary infections: Seedlings which are seriously infected by fungi or bacteria are classified as normal, if it is evident that the parent seed is not the source of infection, and if it can be determined that all the essential structures were present

Abnormal seedlings

An abnormal seedling is one which does not have the capacity to develop into a normal plant when grown in the soil under favorable conditions because one of more of the essential structures is irreparably defective.

Three major classes of abnormal seedlings are:

a) Damaged Seedlings Seedlings with any of the essential structures missing or so body damaged that balanced development does not occur. The damage to the embryo in the seed usually results from external cause i.e., mechanical handing.

b) Deformed or unbalanced seedlings Seedlings with weak and unbalanced development which may be caused by internal disturbances of physiological biochemical character. Such internal disturbances, however, are often due to the earlier external disturbances such as unfavorable growing conditions of the parent plants, poor ripening conditions for the seed, premature harvesting, effect of herbicides or pesticides and inappropriate storage conditions or ageing of the seed.

c) Decayed seedlings: Seedlings with any of their essential structures se diseased or decayed as a result of primary infection that normal development is prevented. These may result from the external or internal seed borne disease.

Staring of Samples

The official samples after testing should be stored in controlled storage (3° C and 50% RH) for a minimum period of two years from the date of grant/extension of the certificate, unless required for longer period. Every care should be taken to protect the samples from insects and rodents.

Determination of seedling vigour

Seedling vigour is in important quality parameter which needs to be assessed to supplement germination and viability test to gain an insight into the performance of a seed lot in the field or in storage. Vigour index was calculated by using the formula suggested by Abdul Baki and Anderson (1973).

(1) Vigour index I-germination percentage x seedling length (cm).
(ii) Vigour index II-germination percentage x seedling dry weight (mg).

Shoot length (cm)

From the germination test, ten normal seedlings were selected randomly in each treatment from all the replications on eighth day. The shoot length was measured from the base of the primary leaf to the base of the hypocotyls and the mean shoot length was expressed in centimeter.

Root length (cm)

Ten normal seedlings used for shoot length measurement, were also used for the measurement of root length. The root length was measured from the tip of the primary root to base of hypocotyls and the moan root length was expressed in centimeter.

Seedling dry weight estimation

After standard germination test 10 normal seedlings were taken at random and their shot and root length were recorded by linear scale. For dry weight these seedlings were kept in an oven at 80° C for 17 hours and then dry weight has been taken with the help of electronic balance.

Accelerated ageing Studies

The test was developed by Deloche and Baskin (1972) at Mississippi State University. Seeds are held at high humidity (usually near 100%), with the result that their moisture content increases, and at temperatures of 40-45° C for varying length of time depending on the type of seeds. This method of rapid ageing is then followed by a germination test. This test was initially developed as a test of seed storage potential where by seeds that retained high germination after accelerated ageing would store well whereas rapid loss of germination was indicative of poor storage potential. Subsequently, the test came into use as a vigour test so that seeds with higher germination were considered high vigour seeds and those with poor germination, low vigour seeds. The application test has however been mainly to predict seed storage potential.

Methods:

The 50 g seeds were treated with carbendazim fungicide powder to avoid any fungal growth interference to artificial ageing of seeds packed in packet of nylon mesh. Nylon mesh (or net) packets are used because these packets does not hold or absorb moisture.

Then the seed packets were placed in desiccators, containing saturated solution of barium chloride to create the internal relative humidity of 90%.

The desiccators containing seed packets were then kept in BOD incubator, at high temperature of 40° C and relative humidity of 90% for different duration of 3 days and 7 days.

After this specific duration of artificial ageing the seeds are removed from the nylon packet and tested for seed germination following standard protocol.

The germination test result is interpreted for high vigour and low vigour seed lots as already mentioned high vigour of seeds will result in higher germination after accelerated ageing than the low vigour seeds.

Results

Effect of herbicide spray at crop maturity on weed population

The soil moisture in the seed production experimental plot and other plots was high due to rainfall during seed crop maturity. High soil moisture caused high weed growth. The total number of weed population in NRC 130 and NRC 86 at crop maturity stage was 218 and 231 in 4x2 m^2 area respectively. The type and intensity of weeds in field of NRC 130 and NRC 86 was almost same. The major weeds were *Euphorbia hirta, Amaranthus viridis, Commelina benghalensis, Echinochloa colona and Cyperus rotundus.*

The time taken to kill weeds by different herbicides was different on the basis of mode of action and type of herbicides. Paraquat dichloride being a contact herbicide it killed most of the weeds in 3 days, followed by broad spectrum systemic herbicide glyphosate which took 6-7 days. The Imazethapyr + Imazamox which is selective herbicide took more than 8 days to kill. The additional effect of paraquat and glyphosate was that soybean plants which were about to dry and had green foliage also became dry along with the weed plants. The selective herbicide Imazethapyr + Iimazamox killed only the weeds bud had negligible effect on soybean plants. (Table 1)

The number of weed plant killed by herbicide was indicated by the reduction in number of weeds after applying 3 types of herbicides Imazethapyr + Imazamox, Glyphosate and Paraquat. High death rate of weed plant was recorded in paraquat followed by glyphosate whereas Imazethapyr + Imazamox has recorded lowest. The number of weeds in NRC 130 and NRC 86 plots were 71 to 78 per 8 m^2. The remaining weed population in the treated plots varied for different treatments. Paraquat treated plot of NRC 130 and NRC 86 had 3 and 4 weeds, Glyphosate treated plots had 14 to 15 weeds and Imazethapyr +Imazamox treated plots had 31 and 32 weeds respectively. The death of weed in case of paraquat was 94 and 96% in NRC 130 and NRC 86, in case of glyphosate it was 81% in both the varieties and in case of Imazethapyr +Imazamox it was 56 and 58% in NRC 130 and NRC 86 respectively. *Cyperus rotundus* was comparatively less affected weeds. Paraquat killed all the weeds in both the varieties except *Cyperus rotundus*. In case of Glyphosate application in both the varieties *Cyperus rotundus* survived more than other weeds in both the varieties. (Table 2)

Table.1 Effect of herbicide spray in death time of weed plant. (Plot size 4x2m^2)

S. No.	Variety Name	Treatment Name	Death time of weed plant
1.	NRC 130	Imazethapyr 35% + Imazamox 35 % WG	8
2.		Glyphosate 41% S.L.	6
3.		Paraquat dichloride 24% S.L.	3
4.	NRC 86	Imazethapyr 35% + Imazamox 35 % WG	8
5.		Glyphosate 41% S.L.	6
6.		Paraquat dichloride 24% S.L.	3

Table 2. Effect of different herbicides applied at crop maturity stage on weed population (Plot size 4x2 m^2)

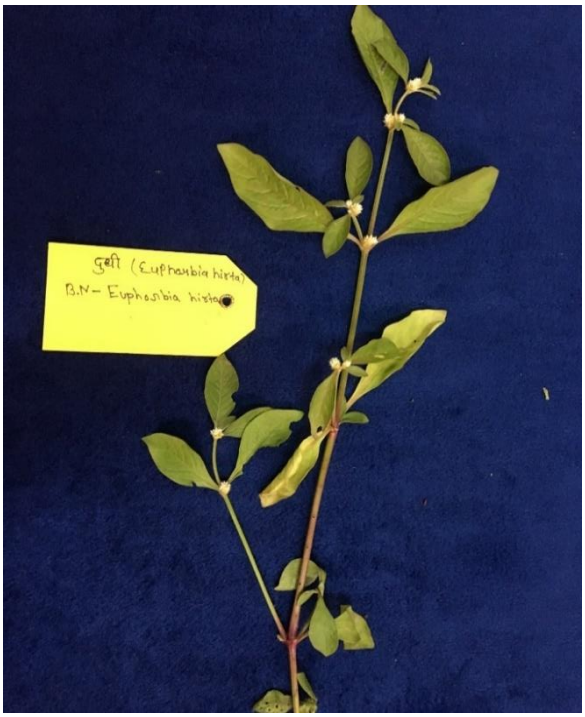
Variety	Treatment Name		*Euphorbia hirta*	*Amaranthus viridis*	*Commelina benghalensis*	*Echinochloa colona*	*Cyperus rotundus*	Total
NRC 130	Imazethapyr + Imazamox	Before spray	15	16	14	15	11	**71**
		After spray	6	5	7	6	7	**31**
	Glyphosate	Before spray	15	14	16	16	14	**75**
		After spray	2	1	4	1	6	**14**
	Paraquat dichloride	Before spray	16	11	17	15	13	**72**
		After spray	0	0	0	0	4	**4**
NRC 86	Imazethapyr + Imazamox	Before spray	12	14	16	18	16	**76**
		After spray	7	7	6	8	4	**32**
	Glyphosate	Before spray	13	19	17	17	12	**78**
		After spray	2	3	4	1	5	**15**
	Paraquat dichloride	Before spray	15	16	18	17	11	**77**
		After spray	0	0	0	0	3	**3**

Plate 1. Experimental plot of variety NRC 130 and NRC 86.

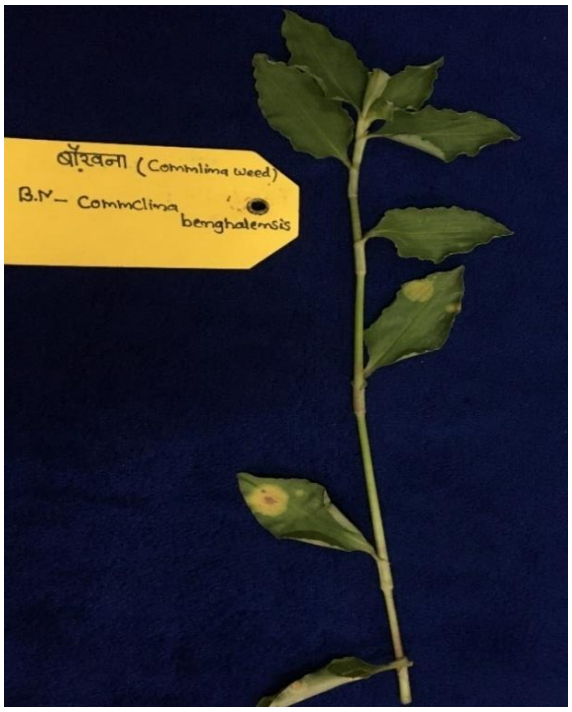
NRC 130

NRC 86

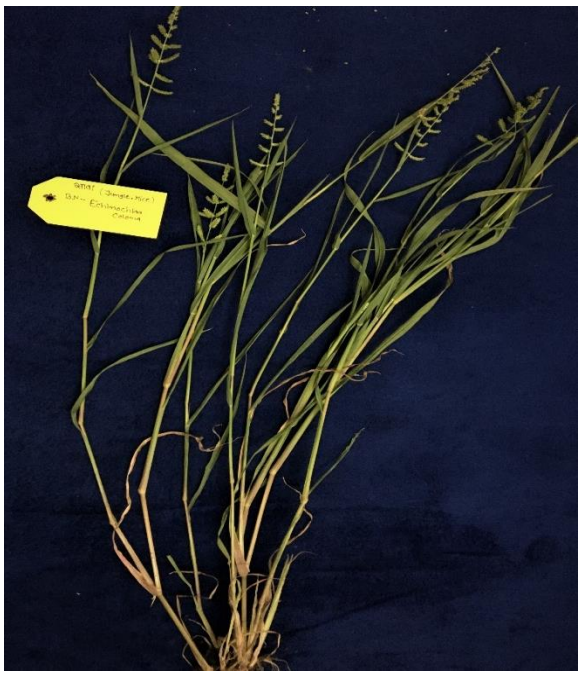
Plate 2. Different weeds observed in NRC 130 and NRC 86.



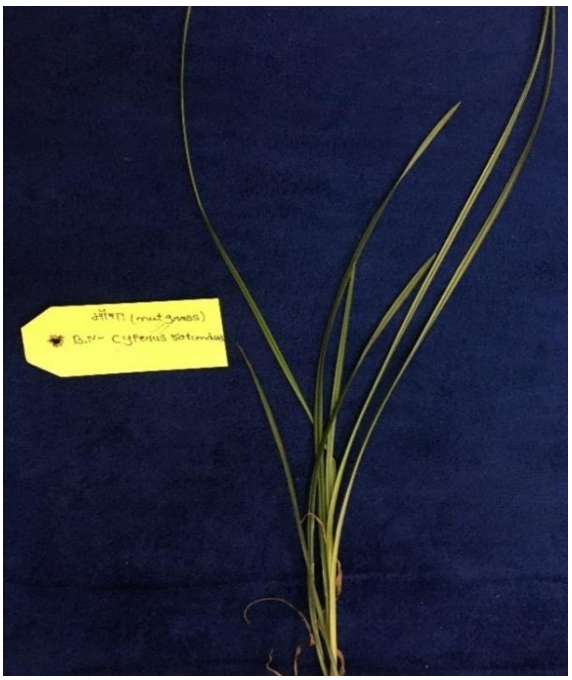
Euphorbia hirta



Commelina benghalensis



Echinochloa colona



Cyperus rotundus

Seed yield (q/ha)

There was no significant difference between the two varieties for seed yield. In which NRC 130 had a higher Seed yield, while NRC 86 had a low Seed yield. There was no significant difference was observed in Seed yield in all the treatments. In variety NRC 130 had higher Seed yield 11.84 q/ha in control and 10.33 q/ha in Imazethapyr + Imazamox treatment. There was no significant difference was observed in Seed yield in the treatment. In variety NRC 86 had higher Seed yield 9.07 q/ha in control and 8.06 q/ha in paraquat dichloride treatment. There is no effect of treatment among the varieties but difference may found among the varieties. (Table 3)

100 Seed Index (g)

There was no significant difference between the two varieties for seed index. In which NRC 130 had a higher Seed index, while NRC 86 had a low Seed index. In variety NRC 130 had higher seed index of 13.5 g in glyphosate treatment and 13.2 g in control. In variety NRC 86 had higher seed index of 9.8 g in treatment glyphosate and 9.7 g in control. There was no effect of treatment on seed index among the varieties. (Table 3)

Effect of herbicides on seed qualities

Seed physical appearance

The weed plants in seed production plots cause problem in seed crop harvesting. The weed plants contain higher moisture than mature soybean crop. Weed plants are also uprooted during harvesting and soil particles are mixed with seeds. The same situation was observed during harvesting of other seed crops of NRC 130 and NRC 86. It was observed that while harvesting weed plants in control plots were mixed with matured soybean plants and also several uprooted weed plants. In this experiment to create similar situation of combine harvesting, soybean seed crops of treatment and control plots were immediately threshed in threshing machine. The impact of weed plants on seed quality was observed as presence of greenish seeds and seeds with soil on surface. This situation was negligible in treated plots as compared to control plots. The physical appearance was poor due to loss of shine on seeds due to green weed plant juice and mud on seed surface.

Table 3. Yield and 100 seed weight

Plot Size 126x3.15 m = 396.9 m^2

S. No.	Variety	Treatment Name	Plot / Kg	q/Ha	100 Seed W.T.
1	NRC 130	Imazethapyr + Imazamox	41	10.33	13.303
2		Glyphosate	46	11.58	13.546
3		Paraquat dichloride	45	11.33	13.358
4		Control	47	11.84	13.236
5	NRC 86	Imazethapyr + Imazamox	33	8.3	9.502
6		Glyphosate	35	8.81	9.766
7		Paraquat dichloride	32	8.06	9.332
8		Control	36	9.07	9.658

Seed Germination Test

Germination test after 15 days of harvesting

Herbicides are chemical that can have detrimental effect on soybean seed germination. The seed germination was tested immediately after harvest to check effect on seed germination. There was significant difference between the two varieties for seed germination. In which NRC 130 had a higher Seed germination, while NRC 86 had a low seed germination.

There was no significant difference observed in seed germination among the treatments and control in NRC 130, but treatments were significantly higher than control in variety NRC 130. In NRC 130 the germination among the control and treatment ranged from 82% in control to 88% in glyphosate treatment. There was Significant difference observed in seed germination in all the treatments, in variety NRC 86 had higher seed germination of 83 % in odyssey treatment and 69 % in control. (Table 4)

Vigour index I

There was no significant difference between the two varieties for vigour index I, in which NRC 86 had a higher Vigour index I, while NRC 130 had a low Vigour index I. There was no Significant difference observed in Vigour index I in all the treatments, in variety NRC 130 had higher Vigour index I of 1861.9 in odyssey treatment and 1810.12 in control. There was no Significant difference observed in Vigour index I, in all the treatments in variety NRC 86 had higher Vigour index I of 1949.67 in odyssey treatment and 1621.5 in control. There was no effect of treatment on Vigour Index I in variety NRC 130 and NRC 86. (Table 5)

Vigour index II

There was significant difference between the two varieties for vigour index II, in which NRC 130 had a higher Vigour index II, while NRC 86 had a low Vigour index II. There was Significant difference observed in Vigour index II in all the treatments, in variety NRC 130 had higher Vigour index II of 139.74 in glyphosate treatment and 130.73 in control. There was Significant difference observed in Vigour index II in all the treatments, in variety NRC 86 had higher Vigour index II of 98.94 in paraquat treatment and 72.86 in control. There was effect of treatment on Vigour Index II in variety NRC 130 and NRC 86. (Table 5)

Germination test after 30 days of harvesting

There was significant difference between the two varieties for seed germination, in which NRC 130 had a higher Seed germination, while NRC 86 had a low seed germination.

There was no significant difference observed in seed germination among the treatments and control in NRC 130, but treatments were significantly higher than control in variety NRC 130. In NRC 130 the germination among the control and treatment ranged from 88% in paraquat treatment to 92% in odyssey. There was Significant difference observed in seed germination in all the treatments, in variety NRC 86 had higher seed germination of 77.5 % in odyssey treatment and 61 % in control. (Table 4)

Vigour index I

There was no significant difference between the two varieties for vigour index I, in which NRC 130 had a higher Vigour index I, while NRC 86 had a low Vigour index I. There was Significant difference observed in Vigour index I in all the treatments, in variety NRC 130 had higher Vigour index I of 1984.4 in odyssey treatment and 1493.1 in control. There was no Significant difference observed in Vigour index I in all the treatments, in variety NRC 86 had higher Vigour index I of 1732.3 in paraquat treatment and 1288.2 in control. There was no effect of treatment on Vigour Index I in variety NRC 130 and NRC 86. (Table 5)

Vigour index II

There was significant difference between the two varieties for vigour index II, in which NRC 130 had a higher Vigour index II, while NRC 86 had a low Vigour index II. There was no Significant difference observed in Vigour index II in all the treatments, in variety NRC 130 had higher Vigour index II of 163.62 in control and 160.82 in odyssey treatment. There was Significant difference observed in Vigour index II in all the treatments, in variety NRC 86 had higher Vigour index II of 88.49 in glyphosate treatment and 68.14 in control. There was effect of treatment on Vigour Index II in variety NRC 130 and NRC 86 and difference may see in varieties. (Table 5)

Germination test after 45 days of harvesting

There was no significant difference between the two varieties for seed germination, in which NRC 130 had a higher Seed germination, while NRC 86 had a low seed germination. There was no significant difference observed in seed germination among the treatments and control in NRC 130, but treatments were significantly higher than control in variety NRC 130. In NRC 130 the germination among the control and treatment ranged from 87.5 % in glyphosate treatment to 92.5 % in paraquat. There was Significant difference observed in seed germination in all the treatments, in variety NRC 86 had higher seed germination of 76 % in paraquat dichloride treatment and 64.5 % in control. (Table 4)

Vigour index I

There was significant difference between the two varieties for vigour index I, in which NRC 130 had a higher Vigour index I, while NRC 86 had a low Vigour index I. There was no Significant difference observed in Vigour index I in all the treatments, in variety NRC 130 had higher Vigour index I of 2538.3 in odyssey treatment and 2212.4 in control. There was no Significant difference observed in Vigour index I in all the treatments, in variety NRC 86 had higher Vigour index I of 1923 in glyphosate treatment and 1611.21in control. There was no effect of treatment on Vigour Index I in variety NRC 130 and NRC 86. (Table 5)

Vigour index II

There was significant difference between the two varieties for vigour index II, in which NRC 130 had a higher Vigour index II, while NRC 86 had a low Vigour index II. There was Significant difference observed in Vigour index II in all the treatments, in variety NRC 130 had higher Vigour index II of 172.98 in paraquat treatment and 141.14 in control. There was Significant difference observed in Vigour index II in all the treatments, in variety NRC 86 had higher Vigour index II of 98.94 in glyphosate treatment and 83.21 in control. There was effect of treatment on Vigour Index II in variety NRC 130 and NRC 86. (Table 5)

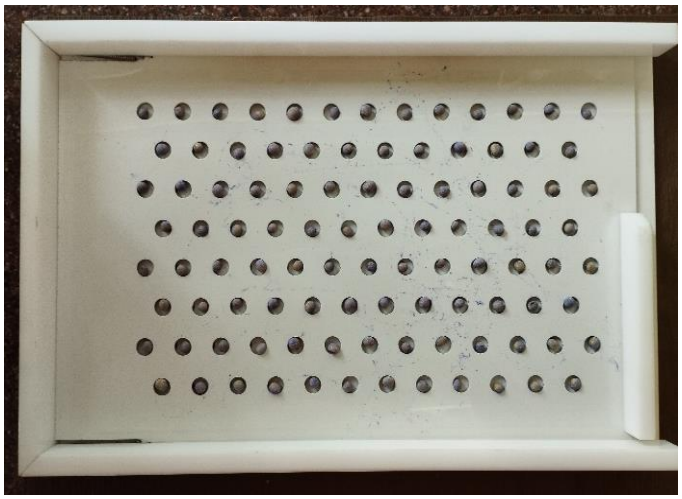
Table 4. Seed Germination Test

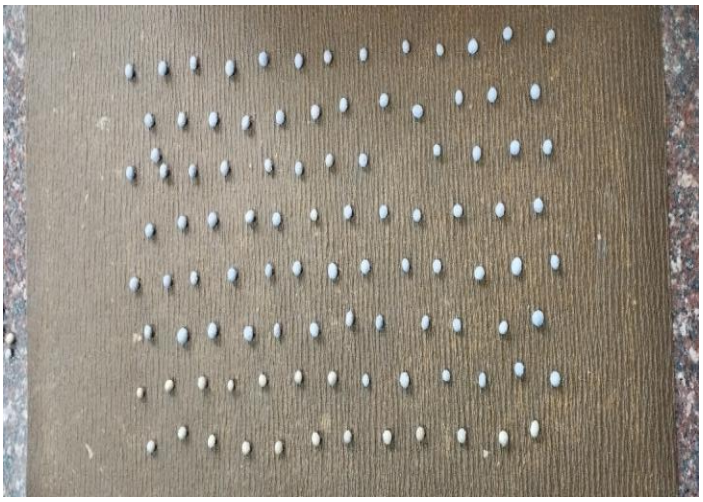
S. No.	Variety	Treatment Name	Germination % After 15 Days	Germination % After 30 Days	Germination% After 45 Days
1	NRC130	Imazethapyr + Imazamox	86	92	90.5
2		Glyphosate	88	89	87.5
3		Paraquat dichloride	86	88	92.5
4		Control	82	91	89.5
5	NRC 86	Imazethapyr + Imazamox	83	67	63.5
6		Glyphosate	75	72	75
7		Paraquat dichloride	82	77.5	76
8		Control	69	61	64.5

Table 5. Seed Vigour

S. No	Variety	Treatment Name	Vigour I			Vigour II		
			15 Days	30 Days	45 Days	15 Days	30 Days	45 Days
1	NRC 130	Imazethapyr + Imazamox	1861.9	1984.4	2538.3	134.50	160.82	142.54
2		Glyphosate	1843.6	1840.2	2005.0	139.74	154.68	136.24
3		Paraquat dichloride	1730.2	1608.4	2523.0	139.62	150.48	172.98
4		Control	1810.2	1493.1	2212.4	130.73	163.62	141.14
5	NRC 86	Imazethapyr + Imazamox	1949.7	1473.3	1463.4	85.49	72.63	73.85
6		Glyphosate	1633.4	1452.4	1923	86.64	88.49	98.78
7		Paraquat dichloride	1929.11	1732.3	1887.4	98.94	78.20	96.06
8		Control	1621.5	1288.2	1611.21	72.86	68.14	83.21

Plate 3. Seed germination in laboratory.





Accelerated Ageing Germination test

Germination test after 3 days of seeds 40º C in BOD

There was significant difference between the two varieties for seed germination, in which NRC 130 had a higher Seed germination, while NRC 86 had a low seed germination.

There was no significant difference observed in seed germination among the treatments and control in NRC 130, but control were significantly higher than treatment in variety NRC 130. In NRC 130 the germination among the control and treatment ranged from 87% in odyssey treatment and 90.5% in control. There was no Significant difference observed in seed germination in all the treatments, in variety NRC 86 had higher seed germination of 79.5 % in paraquat treatment and 76.5 % in control. (Table 6)

Vigour index I

There was significant difference between the two varieties for vigour index I, in which NRC 130 had a higher Vigour index I, while NRC 86 had a low Vigour index I. There was no Significant difference observed in Vigour index I in all the treatments, in variety NRC 130 had higher Vigour index I of 2225.4 in odyssey treatment and 2094.1 in control. There was no Significant difference observed in Vigour index I in all the treatments, in variety NRC 86 had higher Vigour index I of 2307 in paraquat treatment and 1977.5 in control. There was no effect of treatment on Vigour Index I in variety NRC 130 and NRC 86. (Table 7)

Vigour index II

There was significant difference between the two varieties for vigour index II, in which NRC 130 had a higher Vigour index II, while NRC 86 had a low Vigour index II. There was Significant difference observed in Vigour index II in all the treatments, in variety NRC 130 had higher Vigour index II of 345.35 in control and 271.08 in glyphosate treatment. There was Significant difference observed in Vigour index II in all the treatments, in variety NRC 86 had higher Vigour index II of 179.75 in paraquat treatment and 152.16 in control. There was no effect of treatment on Vigour Index II in variety NRC 130 and NRC 86. (Table 7)

Germination test after 7 of seeds 40º C in BOD

There was significant difference between the two varieties for seed germination, in which NRC 130 had a higher Seed germination, while NRC 86 had a low seed germination. There was no significant difference observed in seed germination among the treatments and control in NRC 130, but treatments were significantly higher than control in variety NRC 130. In NRC 130 the germination among the control and treatment ranged from 88 % in control and 93.5 in glyphosate treatment. There was no Significant difference observed in seed germination in all the treatments, in variety NRC 86 had higher seed germination of 84.5 % in glyphosate treatment and 73.5 % in control. (Table 6)

Vigour index I

There was significant difference between the two varieties for vigour index I, in which NRC 130 had a higher Vigour index I, while NRC 86 had a low Vigour index I. There was no Significant difference observed in Vigour index I in all the treatments, in variety NRC 130 had higher Vigour index I of 2313.19 in glyphosate treatment and 2127.8 in control. There was no Significant difference observed in Vigour index I in all the treatments, in variety NRC 86 had higher Vigour index I of 2234.9 in paraquat treatment and 2068.2 in control. There was no effect of treatment on Vigour Index I in variety NRC 130 and NRC 86. (Table 7)

Vigour index II

There was significant difference between the two varieties for vigour index II, in which NRC 130 had a higher Vigour index II, while NRC 86 had a low Vigour index II. There was Significant difference observed in Vigour index II in all the treatments, in variety NRC 130 had higher Vigour index II of 157.52 in control and 145.35 in paraquat treatment. There was Significant difference observed in Vigour index II in all the treatments, in variety NRC 86 had higher Vigour index II of 115.85 in glyphosate treatment and 100.99 in control. There was effect of treatment on Vigour Index II in variety NRC 130 and NRC 86. (Table 7)

Table 6. Accelerated Ageing Germination Test.

S. No.	Variety	Treatment Name	Germination After 3 Days At 40° C in BOD	Germination After 7 Days At 40° C in BOD
1	NRC130	Imazethapyr + Imazamox	87	93
2		Glyphosate	87.5	93.5
3		Paraquat dichloride	88.5	90
4		Control	90.5	88
5	NRC 86	Imazethapyr + Imazamox	77	81
6		Glyphosate	74.5	84.5
7		Paraquat dichloride	79.5	82.5
8		Control	76.5	73.5

Table 7. Seed Vigour of Accelerated Ageing Germination Test.

S. No.	Variety	Treatment Name	Vigour I		Vigour II	
			3 Days	7 Days	3 Days	7 Days
1	NRC 130	Imazethapyr + Imazamox	2225.4	2300.8	283.36	151.78
2		Glyphosate	2222.5	2313.1	271.08	155.21
3		Paraquat dichloride	2224.8	1996.2	330.19	145.35
4		Control	2094.1	2127.8	345.35	157.52
5	NRC 86	Imazethapyr + Imazamox	2192.9	2204.8	161.62	107.00
6		Glyphosate	2039	2135.3	149.52	115.85
7		Paraquat dichloride	2307	2234.9	179.75	103.29
8		Control	1977.5	2068.2	152.16	100.99

Discussion and Conclusion

Seed crop maturity is one of the important stage to harvest quality seeds. The seeds are formed after completion of plant growth stage overcoming several abiotic and biotic stress and quality seeds are about to be harvested at the end of crop growth stage. Factors at that time like high weed growth had been found to interfere with seed harvest and to hamper seed quality. Applying different herbicides at this stage was found to help in controlling the weed. There was no negative effect on physiological parameters, growth, yield and quality of soybean seed. In the studies it was found that paraquat had higher death rate of weeds and weeds were killed in 3 days as compare to other two herbicide which had lower death rate killed weeds in 6-8 days. Hampton and Hebblethwaite (1982) reported that glyphosate can be applied preharvest to cereal crops for control of annual and perennial grasses and broad-leaved weeds. Paraquat, glyphosate, Imazethapyr+ Imazamox was similar to yield of control in both the variety NRC 130 and NRC 86. There was no effect of herbicide on 100 seed weight respectively. Azlin and McWhorter (1981) found that glyphosate applied 7 to 12 days before harvest could be useful in providing future control of perennial weeds without adverse effect on soybean yields and seed quality.

The major objective of this study was to find out if there was any negative effect on soybean seed quality due to application of herbicides at final stage of crop growth and when seeds growth was completed. The residual effect of herbicides may cause adverse effect on seed germination. In the study it was found that there was no effect of herbicide when applied at seed crop maturity stage on seed germination. Germination was tested immediately after harvest, 30 days and 45 days of harvest. There was no negative effect on seed germination and its quality. Seed vigour test (accelerated ageing test) was done and there was no negative effect on seed vigour due to herbicide application. Klingman and Murray (1976) found that there was no effect or only minimal effect on germination and seedling development from the glyphosate herbicide treatment.

In this study, it was found that herbicides both broad spectrum and non-selective can be used to control high weed growth due to late monsoon at crop maturity stage to harvest good quality seed which is still major bottleneck for soybean productivity.

REFERENCES

Abdul-Baki AA, Anderson, JD. 1973. Vigour determination in soybean seed by multiple criteria. Crop Science 13: 630-633.

Abubakar, H. (2020). Influence of Herbicides on Yield, Weight and Size of Soybean Seed.

Agarwal, D.K., Billore, S.D., Sharma, A.N. et al. Soybean: Introduction, Improvement, and Utilization in India—Problems and Prospects. Agric Res 2, 293–300 (2013).

Albrecht, L. P., Barbosa, A. P., Silva, A. F. M., Mendes, M. A., Albrecht, A. J. P., & Ávila, M. R. (2012). RR soybean seed quality after application of glyphosate in different stages of crop development. *Revista Brasileira de Sementes*, *34*, 373-381.

Assad. A. C, and F. E. Romans. 1979. Chemical harvest aid assumes important role in six crops. Weeds Today 10:20-21.

Azlin, W. R., & McWhorter, C. G. (1981). Preharvest effects of applying glyphosate to soybeans (Glycine max). *Weed Science*, *29*(1), 123-127.

Baig, M. N., Darwent, A. L., Harker, K. N., & O'Donovan, J. T. (2003). Preharvest applications of glyphosate affect emergence and seedling growth of field pea (Pisum sativum). *Weed Technology*, *17*(4), 655-665.

Baur, J. R., F. R. Miller, and R. W. Bovey. 1977. Effect of preharvest desiccation with glyphosate on grain sorghum seed. Agron. J. 69: 1015–1018.

Bennett, A.C., Shaw, D.R., 2000b. Effect of preharvest desiccants on Group IV Glycine max seed viability. Weed Science, 48: 426-430.

Blackburn, L.G.; Boutin, C. Subtle effects of herbicide use in the context of genetically modified crops: A case study with glyphosate (Roundup®). *Ecotoxicology* 2003, *12*, 271–285.

Bollich, P.K., Dunigan, E.R., Kitchen, L.M. and Taylor, V. 1988. The influence of trifluralin and pendimethalin on nodulation, N2 (C2H2) fixation and seed yield of field grown soybeans (Glycine max). Weed Sci. 36(1): 15-19.

Burnside, O.C. 1971. Effect of herbicides on seedling emergence force. Weed Sci. Hh 162-184.

Campbell, M.H., Miller, L.G. and Nicol, H.I. (1998). Effect of herbicides on seedhead production and control of serrated tussock (Nassella trichotoma (Nees) Arech.). Plant Prot. Quart. 13(3), 106-10.

Caviness, C. E., & Johnson, D. L. (1971). Effect of foliar applications of paraquat on soybeans. *Arkansas farm research*.

Cerkauskas, R. F., Dhingra, O. D., Sinclair, J. B., & Foor, S. R. (1982). Effect of three desiccant herbicides on soybean (Glycine max) seed quality. *Weed Science*, *30*(5), 484-490.

Chen, C. C, C. H. Andrews, C C Baskin, and J. C. Delouche. 1972. Influence of quality of seed on growth, development, and productivity of some horticultural crops. Proc. Int. Seed Test. Assoc. 37:923-939.

Cole, A. W., and A. L. Cerdeira. 1982. Southern pea response to glyphosate desiccation. HortScience 17:244-246.

Darwent, A. L., Kirkland, K. J., Townley-Smith, L., Harker, K. N., Cessna, A. J., Lukow, O. M., & Lefkovitch, L. P. (1994). Effect of preharvest applications of glyphosate on the drying, yield and quality of wheat. *Canadian journal of plant science*, *74*(2), 221-230.

Delouche, J. C 1974. Maintaining soybean seed quality, p. 46-62 in Soybean: Production, Marketing, and Use. Term. Valley Auth. Bull. Y69. Muscle Shoals, AL.

Demir I, Ashirov A M and Mavi K (2008) Effect of seed production environment and time of harvest on tomato (Lycopersicon esculentum) seedling growth. Res J Seed Sci. 1, 1-10.

Durigan, J. F., N. M. Carvalho, J. C Duragan, and M. Barrejp. 1978. Preharvest application of a desiccant to soybean [Glycine max (L.) Merr.] cv. Vicosa. Cienrifica 6:381-385.

Eastin, E.F., 1980. Preharvest desiccants for rice. Crop Sci. 20, 389–391.

Emine, K., Cetin, K., & Sema, B. (2007). Determination the effect of defoliation timing on cotton yield and quality. *Journal of Central European Agriculture*, *8*(3), 357-362.

Fayte, B., Lavy, L.T. and Talbert, R.E. 1982. Effect of three dinitroaniline herbicides on rice growth. Weed Sci. 30: 153-158.

Fipke, G. M., Martin, T. N., Nunes, U. R., Stecca, J. D. L., Winck, J. E. M., Grando, L. F. T., & da Costa Rossato, A. (2018). Application of non-selective herbicides in the pre-harvest of wheat damages seed quality. American Journal of Plant Sciences, 9(1), 107-123.

Hampton, J. G., & Hebblethwaite, P. D. (1982). The preharvest use of glyphosate in the ryegrass seed crop. Grass and Forage Science, 37(3), 243-248.

Hassawy, G.S. and Hamilton, K.C. 1971b. Effects of trifluralin and organophosphorus compounds on cotton seedlings. Weed Sci. 19: 166-169.

Hess, D. and Bayer, D. 1974. The effect of trifluralin on the ultrastructure of dividing- cells of the root meristerns of cotton. J. Cell Sci. 15: 429-441.

Horvath AA (1926) Changes in the blood composition of rabbits fed on raw soy beans. J Biol Chem 68:343–355.

Hussaini, A. (2014) Effect of panicle position on the mother Plant on oil content and seed germinability of castor seed. MSc thesis University of Agriculture Makurdi.

Hymowitz T (1990) Soybeans: the success story. In: Janick J, Simon JE (eds) Advances in new crops. Timber Press, Portland, OR, pp 159–163.

Jaskulski, D., & Jaskulska, I. (2014). The effect of pre-harvest glyphosate application on grain quality and volunteer winter wheat. *Romanian Agricultural Research*, *31*(1), 283-289.

Jeffery, L. S., J. R. English, and J. Connell. 1981. The effects of fall application of glyphosate on corn (Zea mays), soybeans (Glycine max), and johnsongrass (Sorghum halepense). Weed Sc i 29:190-195.

Khoshoo TN (1995) Census of India's biodiversity; tasks ahead. Curr Sci 69:14–17.

Klingman, D. L., & Murray, J. J. (1976). Germination of seeds of turfgrasses as affected by glyphosate and paraquat. *Weed science*, *24*(2), 191-193.

Kolhe, S.S., Miltra, B.N., Meur, S.K. and Bhadauria, S.S. 1984. Influence of preemergence herbicide on germination and growth parameters of paddy. Indian J. Weed Sci. 16: 207-209.

Kumar, S. (2012). Effect of Herbicides on Carbohydrate, Protein and Electrophoretic Protein Bands Content in Triticum Aestivum L, 2(1): 13–25.

Kust, C.A. and Struckmeyor, B.E. 1971. Effects of trifluralin on growth, nodulation and anatomy of soybeans. Weed Sci. 19: 147-152.

Lamego, F. P., Gallon, M., Basso, C. J., Kulczynski, S. M., Ruchel, Q., et al. (2013). Dessecação pré-colheita e efeitos sobre a produtividade e qualidade fisiológica de sementes de soja. Planta Daninha, 31(4): 929–938. https://doi.org/10.1590/S0100- 83582013000400019.

Malalgoda, M., Ohm, J. B., Ransom, J. K., Howatt, K., & Simsek, S. (2020). Effects of pre-harvest glyphosate application on spring wheat quality characteristics. Agriculture, 10(4), 111.

Manthey, F. A., Chakraborty, M., Peel, M. D., & Pederson, J. D. (2004). Effect of preharvest applied herbicides on breadmaking quality of hard red spring wheat. Journal of the Science of Food and Agriculture, 84(5), 441-446.

McNaughton, K. E., Blackshaw, R. E., Waddell, K. A., Gulden, R. H., Sikkema, P. H., & Gillard, C. L. (2015). Effect of application timing of glyphosate and saflufenacil as desiccants in dry edible bean (Phaseolus vulgaris L.). Canadian journal of plant science, 95(2), 369-375.

Mishra, P., Singh, H., & Pal, S. B. S. (2013). Bio-efficacy of some early post-emergence herbicides in soybean (Glycine max L.). transformation, 10, 0-5.

Oliver, L.R. and Frans, R.E. 1965. Influence of trifluralin rate and depth of incorporation on cotton and soybean lateral root development. Proc. South Weed Conf. 18: 85-91.

Pahwa, S.K., Prakash, J. and Sharma, H.R. 1988. Effect of herbicides on' the growth, nodulation and symbiotic nitrogen fixation in pigeon pea. Crop Res. 1(2): 131-140.

Parmar, P. S., Vishwakarma, A. K., Sharma, K. C., & Baghel, M. (2017). Study on Effect of Different Herbicides on Weed intensity and Dry weightunder rain-fed Condition of central India in Soybean [Glycine max (L.) Merrill]. Journal of Pharmacognosy and Phytochemistry, 6(6S), 102-110.

Perboni, L. T., Agostinetto, D., Vargas, L., Cechin, J., Zandoná, R. R., & Farias, H. D. S. (2018). Yield, germination and herbicide residue in seeds of preharvest desiccated wheat. *Journal of Seed Science*, *40*, 304-312.

Prakash, J. and Pahwa, S.K. 1984. Effect of some new herbicides on growth of pea plants. Pesticides. 18(7): 56-58.

Pratap, Aditya & Gupta, S. & Kumar, Jitendra & Solanki, Ramesh. (2012). Soybean. 10.1007/978-1-4614-0356-2_12.

Probst AH, Judd RW (1973) Origin, US history and development, and world distribution. In: Caldwell BE (ed) Soybean: improvement, production, and uses. Agron monograph 16. Is ted. ASA, CSSA, and SSSA, Madison, pp 1–15.

Ratnayake, S., & Shaw, D. R. (1992). Effects of harvest-aid herbicides on soybean (*Glycine max*) seed yield and Quality. *Weed Technology*, *6*(2), 339-344.

Ratnayake, S., & Shaw, D. R. (1992). Effects of harvest-aid herbicides on sicklepod (Cassia obtusifolia) seed yield and quality. *Weed Technology*, *6*(4), 985-989.

Rosado, C. B., Pereira, G. A. M., Capobiango, N. P., Moreira, R. P. L., Freitas, F. C. L., Teixeira, M. F. F., & Silva, A. A. D. (2019). Physiological quality of bean seeds after application of desiccant herbicides. *Ciência Rural*, *49*.

Scholtes, A. B., Sperry, B. P., Reynolds, D. B., Irby, J. T., Eubank, T. W., Barber, L. T., & Dodds, D. M. (2019). Effect of soybean growth stage on sensitivity to sublethal rates of dicamba and 2, 4-D. Weed Technology, 33(4), 555-561.

Schultz, D.P. 1967. Effects of trifluralin on nucleic acid metabolism and other physiological respnoses. Ph.D. dissertation. Auburn Univ., Auburn. 86 pp.

Semidey, N., & Almodovar, L. (1987). Oxyfluorfen: A candidate herbicide for weed control in pigeon peas. *J. Agric. Univ. PR*, *71*(3), 277-85.

Shad, R. A., & Chaudhry, S. A. (1985). EFFECT OF TRIFLURALIN ON GERMINATION, GROWTH AND NODULATION IN CHICKPEAS (CICER ARIETINUM L). *Arab Journal of Plant Protection*.

Singh RJ, Hymowitz T (1999) Soybean genetic resources and crop improvement. Genome 42:605–616.

SLIFE, F. W. 1956. The effect of 2,4-D and several other herbicides on weeds and soybeans when applied as postemergence sprays. Weeds 4:61-68.

SOPLIN, V. H. (1981). SOME EFFECTS OF PRE-HARVEST DESICCATION ON SOYBEAN (GLYCINE MAX (L.) MERR.) SEED QUALITY.

Standifer, L.C. and Thomas, C.H. 1965. Response of johnsongrass to soil incorporated trifluralin. Weed Sci. 13: 302-308.

Swann, C. W. and Behrens, R. 1972. Phytotoxicity of trifluralin vapours from soil. Weed Sci. 20: 143-146.

Swanson, C.R. 1972. Dinitroaniline herbicides; biological activity, structure, relationships and mode of action. 87-112 In A.S. Taheri, ed. Herbicides, fungicides, formulation chemistry. Gordan and Breach, New York.

Wax, L. M., Knuth, L. A., & Slife, F. W. (1969). Response of soybeans to 2, 4-D, dicamba, and picloram. *Weed Science*, *17*(3), 388-393.

Whigham, D. K. and E. W. Stoller. 1979. Soybean desiccation by paraquat, glyphosate, and ametryn to accelerate harvest. Agron. J. 71:630–634.

Wilcox, J. R., F. A. Laviolette, and K. L. Athow. 1974. Deterioration of soybean seed quality associated with delayed harvest Plant Dis. Rep. 58:130-133.

Wilson, R. G., & Smith, J. A. (2002). Influence of harvest-aid herbicides on dry bean (Phaseolus vulgaris) desiccation, seed yield, and quality. *Weed technology*, *16*(1), 109-115.

Yenish, J. P., & Young, F. L. (2000). Effect of preharvest glyphosate application on seed and seedling quality of spring wheat (Triticum aestivum). *Weed Technology*, *14*(1), 212-217.

Zagonel, J. (2005). Herbicide application timing in preharvest desiccation of soybean cultivars with different growth habits. Journal of Environmental Science and Health. Part. B, Pesticides, Food Contaminants, and Agricultural Wastes, 40(1): 13–20.

Zollinger, R.K.; Manthey, F.A.; Fitterer, S.A. Effect of preharvest herbicides on durum wheat quality. In Proceedings of the 52nd Western Society of Weed Science, Colorado Spring, CO, USA, 8–11 March 1999; p. 103.