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LIST OF ABBREVIATIONS

%	:	Per cent
@	:	At the rate of
ARS	:	Agricultural Research Station
CD	:	Critical difference
cm	:	Centimeter
CMIE	:	Cloth bag
cv	:	Cultivar
DAS	:	Days after sowing
DI	:	Disease incidence
EC	:	Electrical conductivity of seed leachates
EI	:	Emergence index
FFC	:	Total fungal colonies
g	:	Gram
ha	:	Hectare
ISTA	:	International Seed Testing Association
K	:	Potash
kg	:	Kilogram
m^2	:	Square meter
mg	:	Milligram
N	:	Nitrogen
NS	:	Non significant
P	:	Phosphorus
PLCB	:	Polylined cloth bag
q ha^{-1}	:	Quintals per hectare
q	:	Quintal
SVI	:	Seedling vigour index

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ABSTRACT

Freshly harvested seeds of popular soybean varieties LSB-3, JS-335 and MACS-450 were collected from Agricultural Research Station, Adilabad and treated with bioagents (*Trichoderma viride*, *Trichoderma harzianum*, *Bacillus substillis* and *Pseudoman fluorescens*) and fungicides (thiram, thiram + carbendazim) and maintaining untreated control. After seed treatment the seeds were sown in field with three replications duly adopting Split Plot Design in order to find out the effect of seed treatments on incidence of seed borne diseases, plant growth parameters, yield and yield components. After seed treatment another portion of seed material of the above soybean genotypes were packed in cloth bag and polylined cloth bag for assessment of seed quality, seedling vigour and storability and data were subjected for Factorial Randomized Block Design (FRBD).

The germination percentage, seedling vigour, field emergence and storability were high in seed treatments particularly thiram, thiram + carbendazim and *T.viride* as a result of suppression of seed borne mycoflora and maintenance of strong membrane integrity. Seeds packed in vapour proof container (polylined cloth bag) were also effective in improving the seed quality, seed germination, seed health, seedling vigour and storability in all the soybean genotypes.

Total dry matter production, number of seeds per pod, number of seeds per plant, plant stand, 100 seed weight, seed recovery percentage, seed yield per plant and seed yield per hectare were increased with seed treatments

particularly thiram, thiram+carbendazim and *T.viride*. An untreated plot recorded 987 kg ha^{-1} and it was inferior to seed treatments. The additional increase of yield per hectare over control were 616, 508, 346 kgs in LSB-3, 941, 836, 668 kgs in JS-335 and 851, 655, 569 kgs in MACS-450 with thiram, thiram + carbendazim and *T.viride* respectively.

Thus it is recommended that seed treatments in soybean either with thiram or thiram + carbendazim and *T.viride* were found effective and beneficial to the farmers for reducing the incidence of seed borne pathogens (*Cercospora kikuchi, Colletotrichum dematium, Alternaria alternate, Macrophomina phaseolina,* Soybean mosaic virus, leaf crinkle virus, yellow mosaic virus and peanut bud necrosis virus) and getting better quality seed and yield in soybean genotypes.

CHAPTER I

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is one of the most important oilseed crop for its excellent protein (42-45%), oil (22%) and starch content (21%). The crop occupied second position after groundnut due to its higher compound growth rate of production during the last decade. In India the crop is grown in an area of 58.7 lakh ha with annual production of 45.58 lakh tonnes. The productivity is only 0.78 t/ha as compared to the world's soybean average productivity of 2.24 t/ha (CMIE, 2003). Mainly the crop is grown in the states like Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Uttar Pradesh and Andhra Pradesh. In Andhra Pradesh the crop is grown in an area of twenty thousand hectares with total production of twenty thousand tonnes and productivity of one ton per ha which is comparatively higher than the average productivity of country. Soybean cultivation is gaining importance at faster pace in Andhra Pradesh. The crop is extensively grown in places like Adilabad, Guntur and Prakasam districts.

In general soybean seeds have poor storability, which looses vigour and viability very rapidly under the influence of adverse storage conditions and it is susceptible to various seed borne diseases. The annual losses due to soybean diseases are estimated to the tune of 12 per cent of the total production. Occasionally the losses due to viral diseases may go up to 50 per cent (Sinclair,

1982) and reduces yield and quality of seeds (Rehman *et al.,* 1993). The association of seed borne mycoflora is responsible for deteriorating seed quality during seed storage.

For successful production of any crop the seed must be sound and free from mycoflora which are likely to interfere with germination, emergence and subsequent performance of the crop in the main field. Under field conditions seeds are known to harbor several fungi, which affect their health seriously causing germination failure, partial to complete death of seedlings. Seed borne pathogens declines seed viability and vigour both in storage and field conditions and causes yield losses subsequently in the field (Anuja and Aneja, 2000).

In recent years, use of bioagents was also found very effective in controlling diseases (Cook and Baker, 1983). Some of the potential bioagents that could be employed for management of seed borne pathogens are *Trichodeerma viride, T. harzianum, Bacillus subtillis* and *Pseudomonas fluorescens* (Ramanatham and sivaprakasam, 1993). Seed treatments with fungicides were found most effective in checking seed borne diseases both in field and storage conditions (Meenakumari *et al.,* 2002). In view of the above, the present investigation was carried out with seed treatments (bioagents and fungicides) and stored in cloth bag and polylined cloth bag with the following objectives.

1. To find out the effect of bioagents and fungicides on seed quality and yield.
2. To find out the efficacy of bioagents and fungicides on seed borne diseases of soybean under field conditions.
3. To find out the suitable seed treatments (bioagents, fungicides) and containers for maintenance of vigour and storability of soybean genotypes.

CHAPTER II

REVIEW OF LITERATURE

The available literature on "Effect of seed treatment with bioagents and fungicides on seed quality and yield of soybean genotypes" is dealt in this chapter under the following headings.

2.1 Seed mycoflora of soybean genotypes .
2.2 Effect of seed treatments on seed quality parameters
2.2.1 Seed treatment with fungicides
2.2.2 Seed treatment with bioagents
2.3 Effect of seed treatment on storability and seed health
2.3.1 Seed treatment with fungicides
2.3.2 Seed treatment with bioagents
2.4 Effect of storage containers on storability and seed health.
2.5 Efficacy of seed treatments on seed borne pathogen of soybean under field conditions.
2.5.1 Seedling emergence
2.5.2 Seedling mortality
2.5.3 Disease incidence
2.5.4 Growth attributes
2.5.5 Yield attributes
2.5.6 Seed recovery percentage
2.5.7 Seed quality parameters

2.1 SEED MYCOFLORA OF SOYBEAN GENOTYPES

Tripathi and Singh (1991) screened three soybean genotypes for seed mycoflora in various localities of Uttar Pradesh which yielded sixteen fungal species namely *Alternaria alternata, Aspergillus flavus, Aspergillus niger, Aspergillus tenuissima, Aspergillus nidulans, Aspergillus terreus, Aspergillus sydowi, Penicillium oxalicum, Fusarium moniliforme, Mucor racemosus, Mucor subtilissimus, Curvularia lunata, Rhizopus arrhizus, Myrothecium roridum and Nigrospora oryzae.*

Anwar *et al.* (1995) reported that 10 field fungi were found associated with soybean genotypes viz., *Alternaria alternata, cercospora kikuchi, colletotrichum truncatum, colletotrichum dematium, Fusarium equiseti, Fusarium moniliforme, Fusarium pallidoroseum, Fusarium oxysporum, Fusarium solani* and *Macrophomina phaseolina* causing root diseases and dampingoff which reduced the seed germination and seedling emergence.

Murthy and Raveesha (1996) studied mycoflora of soybean and reported 38 fungal species among which *Aspergillus, Penicillium* and *Rhizopus* were commonly occurring storage fungi and *Alternaria, Chaetomium, Colletotrichum, Cladosporium, Diaporthe, Fusarium, Macrophomina, Myrothecium, Phoma and Trichothecium* were the most commonly occurring field fungi. Further he reported that most of the fungi reduced seed germination and seedling vigour and caused varied symptoms on seedlings.

Al-kassim (1996) isolated fifteen species of fungi belonging to the genera *Alternaria, colletotrichum, curvularia, Epicocum, Fusarium,* *Penicillium* and *Stemphyllium* from the seeds of okra, capsicum, radish and soybean.

Solanke *et al*. (1997) observed the incidence of *Aspergillus niger* and *Fusarium moniliforme* was higher than *Curvularia lunata, Alternaria alternata* and *Penicillum sps* in PK-472.

2.2 SEED TREATMENTS AND CONTAINERS ON STORABILITY

2.2.1 Seed treatments with fungicides

Ravikumar *et al.* (1987) reported that seeds of soybean treated with fungicides reduced seed mycoflora maintained high germination and vigour index when compared with untreated seeds.

Vanangamudi (1988) studied the effect of seed treatments and storage containers on the viability of fifteen varieties of soybean. The results indicated that seeds treated with captan 2g + DDT 0.2g / kg seed and stored in paper aluminium foil polyethylene laminated pouches were found to record high viability and vigour (root and shoot length) than those stored in cloth bag.

Charjan and Tarar (1992) studied the efficacy of seed treatments in soybean cv. MACS-13 under storage conditions and reported that storability in polythene bags was proved better in terms of seed germinability and lesser seed invasion by the fungal flora during storage than cloth bags and jute bags. Among different seed treatments thiram (0.3%) proved to be superior in increasing germination percentage followed by captan, carbendazim and captafol.

Solanke *et al.* (1998) reported that soybean genotypes PK-472 and MACS-13 treated with thiram, captan, mancozeb, carbendazim and thiram + carbendazim and stored in cloth bags could maintain its viability above certification standard upto six months from harvest. However germination percentage and vigour index were significantly superior in thiram, captan and mancozeb with significant reduction in seed mycoflora than other fungicidal seed treatment and control in both the cultivars.

Savithri *et al*. (1998) reported that seeds of groundnut cv. TMV-2 treated with fungicides, insecticides and fungicide – insecticide combination and stored in cloth bag and polythene bags of 600 guage revealed that seed treatment with thiram @ 3g kg^{-1} controlled seed borne fungi and maintained seed viability and vigour upto 18 months in polythene bags.

Anuja *et al.* (2000) reported that soybean cv. JS-80-21 and pusa –16 seeds treated with mancozeb, thiram, nimbecidine or bleaching powder and stored in cloth or polythene bags for 16 months revealed that storage in polylined bags showed better performance than cloth bags.

Anuja *et al.* (2001) observed that irrespective of seed treatments the per cent occurrence of thermophilic, thermo tolerant flora was 29.8 per cent as against 70.2 per cent of mesophilic flora. Out of two storage containers tested polylined bag harboured low incidence of mycoflora (37.6%) as compared to cloth bag packaging (62.4%). Amongst different seed treatments mancozeb (78.6%) and thiram (65.1%) controlled seed mycoflora more effectively than seed treatments with nimbecidene (10.1%) and bleaching powder (13%) when stored under ambient conditions.

Meena kumari *et al.* (2002) reported that soybean cv. JS-335 and PK-472 treated with thiram maintained germination above minimum seed certification standard up to 10 months of storage with less number of fungal colonies in cloth bag after which the germination fell below certification standard.

Raja *et al.* (2003) observed that green gram seeds treated with neem oil @ 10 ml kg^{-1} and stored in polylined cloth bag showed higher viability and vigour than seeds treated with thiram 2g kg^{-1} and stored in cloth bag and polylined cloth bag.

2.2.2 Seed treatments with bioagents

Jeevalatha (2004) reported that rice hybrids DRRH1 treated with thiram and *Pseudomonas fluorescens* maintained higher seedling vigour index when stored in polythene bag for 8 months as compared to untreated seed stored in cloth bag.

2.3 STORAGE CONTAINERS ON STORABILITY AND SEED HEALTH

Arulnandhy and Senanayake (1988) reported that seeds of three soybean cultivars stored in polyethylene bags maintained significantly higher viability and vigour for a period of 9 months as compared to three months by seeds stored in clay pot closed metal can and paper bag. They have observed remarkable fluctuation in the moisture content of seeds that were stored in containers other than polythene bag which minimized moisture fluctuation in stored seeds may be the appropriate container for storing soybean seeds in humid tropics.

Vanangamudi (1988) reported that seeds stored in paper aluminium foil polythene laminated pouches recorded higher germination, root and shoot length than those stored in cloth bags at all periods of storage.

Rajendra *et al.* (1990) reported that decrease in seed germination percentage in three varieties of soybean was accompanied by an increase in the leaching of electrolytes is an indicator of seed storability and germinability.

Soybean seeds with 4.3 per cent moisture and stored in sealed containers recorded (90%) germination after 28 months of storage as compared to seeds with 10 per cent moisture and stored in gunny bags maintained standard germination of 70 per cent for 12 months. However seeds with sealed containers maintained standard germination for six months (Singh and Hari Singh, 1992).

Singh and Dadlani (2003) reported that soybean cv. PK-327 and JS-71-05 recorded germination of 89 and 99% respectively in polythene bags after storing for a period of six months, where as in cloth bags the per cent germination was 13 and 35% respectively. Polythene bags maintained the germinability above 70% for the period of 14 months while the seeds packed in cloth bags lost the germination beyond four months and also there was significant improvement in seedling dry weight of 57.6 and 40.1 mg after 6 and 14 months of storage in polylined cloth bags as compared to dry weight of 47.4 mg and 14.5mg, respectively in cloth bags and electrical conductance of the seed leachates increased in cloth bag as compared to with polythene bag. CV. JS-71-05 was more vigours than PK-325.

2.4 SOYBEAN GENOTYPES AND STORABILITY

Genotypic differences in soybean storability were reported by Banumurthy and Gupta (1981).

Arulnandhy and Senanayake (1991) reported that seeds of five soybean genotypes differed significantly in viability and vigour at all periods of storage and greater change in seed moisture coinciding with a larger loss in viability and vigour was evident under ambient conditions than controlled storage conditions.

Pushpendra and Kamendrasingh (2002) reported the differences among the varieties for seed longevity. Further they have observed germination and seedling vigour decreased in all the varieties with increase in duration of storage.

2.5 EFFICACY OF SEED TREATMENTS UNDER FIELD CONDITIONS

2.5.1 Seedling emergence

Sunderesh and Hiremath (1982) reported that increase in germination and emergence of soybean due to fungicidal treatment.

Singh and Agarwal (1988) tested different seed dressing fungicides and found that captafol and thiram resulted in the highest seedling emergence. While thiram, captafol and mancozeb increased yields compared with control.

Kawale *et al.* (1989) studied the efficacy of seed treatment fungicides viz., thiram, carbendazim and mancozeb and insecticide (disulfoton) and herbicide (prometryn) as seed treatments in soybean. All seed treatments increased the seedling emergence to an extent of 96 to 98 per cent as compared with 70 per cent in untreated control and increased yields to 1052-1516 kg per ha as compared to untreated control (849 kg per ha).

Tripathi and Singh (1991) studied the efficacy of seed treatment with fungicides which gave significantly better plant stand and yield as compared to control. Seed treatment with captan, thiram, agrosan and mancozeb results in maximum plant stand and significantly improved yield of soybean.

Chung and Ju (1993) reported that treatment of soybean seed with benoram (20% benomyl + 20% thiram) improved seedling emergence rate and increased length of hypocotyls.

Anuja et *al.* (2000) reported that soybean cv. JS-80-21, JS-71-05, MACS-58 and PUSA-16 seeds treated with four different fungicides viz., captan, thiram mancozeb and carbendazim showed significant improvement in field emergence and seed yield during *kharif* 1995. During 1996, soybean cv. JS-80-21 and PUSA-16 seeds treated with mancozeb, thiram, nimbicidine or bleaching powder and stored in cloth or polythene bags for 16 months before sowing. Among different seed treatments thiram treated seeds in polythene bag storage showed significant improvement in field emergence and seed yield.

Raj *et al.* (2002) reported that thiram seed treatment @ 2g kg^{-1} seed significantly improved germination and field emergence and reduced seed mycoflora under laboratory conditions

2.5.2 Seedling mortality

Gayathri and Indra (2003) reported that per cent disease incidence of pre emergence seedling rot was reduced to 88.05 per cent in seed treatment with *T. viride* along with soil application of *T. viride* and neem cake followed by seed treatment with *T.viride* and carbendazim (70.66%) in groundnut seeds affected by *Aspergillus niger* . Root and shoot dry weight and pod yield was also maximum in seed treatment with *T. viride* along with soil application of *T. viride* and neem cake.

Solanke *et al*. (1997) reported that soybean genotypes viz., PK-472, MACS–450 treated with thiram improved germination and controlled pre and post emergence mortality caused by *Aspergillus flavus, Aspergillus niger* and *G. fujikuroi.*

Singh (1997) reported that soybean cv. PK-472 and Punjab–1 treated with carbendazim + thiram @ 0.3% reduced the seed borne infection and increased the germination in the field.

Gupta and Anasari (1998) reported the efficacy of biological agents (*P.fluorescens* and *T. viride*) against seedling mortality. The results revealed that mortality was reduced maximum with *T. viride* and *P. fluorescens* separately and in combination with fungicide and bioagent seed treatments that enhanced the germination over control.

2.5.3 Disease incidence

Hussain *et al.* (1990) reported that infection of *Macrophomina phaseolina* was reduced by treating the sunflower and mung bean seeds with *T. harzianum*, *Gliocladium virens* and *Streptomyces sps* which gave promising control of charcoal rot disease.

Hall and Xue (1995) reported that carboxin + thiram (as vitaflo-280) increased seedling emergence, plant stand, seed yield and decreased the severity of stem infection when applied to discoloured and shrivelled seeds of soybean.

Rahman *et al.* (1995) reported that PK-472 gave higher seedling emergence than cultivar bragg. Seed treatments with thiram gave consistently higher emergence than untreated seed irrespective of sowing dates. They have reported alternaria leaf spot (*Alternaria alternata*), anthracnose(*Colletotrichum dematium*), cercospora leaf spot (*Cercospora kikuchi*), Pod rot and blight (*Fusarium semitectum*) and rhizoctonia aerial blight (*Rhizoctonia soloni*) was higher in early sown crops as compared with late sown crop. The cultivar reaction indicated that disease severity was high in cultivar bragg than cultivar PK-472.

Pannerselvam and saravanamuthu (1996) studied the effect of *T. viride* on growth of *Sarocladium oryzae* the causal agent of sheath rot of paddy and results indicated that *T. viride* caused maximum percentage of growth inhibition of *Sarocladium oryzae*.

Raguchander *et al.* (1998) reported that seed treatment of *T. viride* (4g kg^{-1}) along with farm yard manure and neem cake supported the production of maximum number of chlamydospores, better native rhizobium nodulation and higher yield. The application of *T. viride* greatly reduced charcoal rot incidence compared with *Bacillus subtilis.*

Parakhia *et al.* (1998) reported that biocontrol agents applied as seed treatment with *Bacillus sps, Pseudomonas fluorescens and T.harzianum* to groundnut seeds were moderately effective in controlling seed borne diseases and increasing pod yield.

Tylkowska (1998) observed that seed treatment of onion with *Trichoderma sps* were more effective in controlling seed borne fungi like *Botrytis* than seeds treated with fungicides (benomyl + thiram) and metalaxyl combined treatment were in general as effective as biological treatments alone.

Umesha (1998) tested commercial formulation of *P.fluorescens* as seed treatment against *Pennisetum glaucum* causing downy mildew in pearl millet. Treated seeds increased seedling vigour and inhibited sporulation of downymildew pathogen. *P.fluorescens* controlled downy mildew by both seed treatment and foliar application but seed treatment was more effective than foliar application alone.

Das and Datta (1999) assessed the efficacy of *T. harzianum* as seed treatment along with four different carriers of sublethal doses of thiram against stem rot of soybean caused by *Rhizoctonia solani*. Lowest disease index was observed when seeds were treated with *T. harzianum* +methyl cellulose with significant increase in dry weight of root, shoot and yield over inoculated control. Sub lethal doses of thiram when mixed with antatgonist as seed treatment showed lower disease index than the lethal doses of thiram alone.

De and Chaudhary (1999) reported that seed treatment of lentil with *T. viride* reduced wilt incidence by 79 per cent and increased yield by 241 per cent followed by seed treatment with *pseudomonas fluorescens* + carboxin which decreased wilt incidence by 65 per cent and increased yield by 229 per cent.

Gaulart *et al.* (2000) reported the efficacy of fungicidal seed dressings on the control of soybean seed borne pathogens and reported that fungicidal seed treatments reduced the incidence of *Phomopsis sps, Fusarium semitectum, Colletotrichum truncatum and Cercospora kikuchi.* Further they have reported that improvement in crop yield when seeds were treated with thiram and carbendazim.

Vimala *et al.* (2000) reported that seed treatment of groundnut with *T. viride, T. hamatum, P. fluorescens* and *rhizobium sps* significantly reduced root rot incidence as compared with control. *T. hamatum* applied as soil application and seed treatment recorded significantly lower root rot incidence (5.67%) and higher mean dry pod yield (1955 kg ha^{-1}).

Prasad (2001) reported that *Trichoderma sps.* applied as seed treatments to chickpea causing root and collor rot were superior to fungicide captan and showed good plant growth promoting ability and rhizosphere competency.

Jahagirdar *et al.* (2002) reported that seed treatment of *T. viride* (4.5g kg^{-1}) combined with soil application of the same showed lowest wilt incidence followed by seed treatment of *T. viride* alone, *P. fluorescens* has only moderate effect on wilt control.

Manmeet *et al.* (2002) evaluated four antagonists namely *Bacillus subtilis, P.fluorescens, T.harzianum* and *Penicillium notatum* against *Xanthomonas oryzae* inciting bacterial leaf blight in rice. *P. fluorescens* and *T.harzianum* significantly reduced disease intensity when applied as foliar and seed treatments.

Meena kumari *et al.* (2002) reported that JS-335 recorded maximum incidence of diseases as compared to PK-472. The average incidence of soybean mosaic virus in these two genotypes were (4 and 1.5%), yellow mosaic virus (2.6 and 1.3%), leaf crinckle virus (1.6 and 1.1%), anthracnose (10 and 10%), cercospora leaf spot (25 and 17.5%) and charcoal rot (3 and 2.5%). Maximum reduction in 1000 seed weight was observed in JS-335 due to the influence of seed borne diseases as compared to that of PK- 472.

Vrataric (2002) reported that foliar application of fungicides in soybean genotypes recorded a better control of pod and stem blight caused by *Diaporthe phaseolorum var-sojae* as compared with seed dressing of same group of fungicides.

2.5.4 Growth attributes

Lakshmi *et al.* (1998) reported that soybean cv. bragg treated with 0.2% thiophanate methyl showed significant improvement in germination and shoot: root ratio as compared with untreated seeds.

Negalur *et al.* (2001) studied the effect of seed treatment with thiram, water, NAH_2PO_4 (5%), potassium iodide (2.5%), Tocopherol (1%), Ascorbic acid (2%), carbendazim (0.1%), thiourea (1%) and KH_2PO_4 (2%) on the growth and yield of soybean cv. JS-335. The results indicated that plant growth, seed yield, yield components (plant height at harvest, number of leaves, branches, pods and seeds and 100 seed weight) were significantly affected by seed treatment.

Sushma *et al.* (2003) reported that soybean cv. JS-335-80-21 treated with captan +carbendazim was found superior followed by thiram+carbendazim and thiram alone in terms of field emergence, less mortality, plant height, nodulation and yield.

2.5.5 Yield attributes and yield

Thombre *et al.* (1989) reported that MACS-13 treated with thiram, captafol, mancozeb, brassicol, carbendazim and sulphur significantly increased the grain yield and plant stand.

Taywede *et al.* (2002) studied the effect of seed dressing chemicals and found that treatments with *rhizobium* + thiram increased the seed yield of soybean to 2756 kgs per ha.

Vrataric (2002) observed significant improvement in grain yield and 1000 seed weight in seeds dry dressed with fungicides and foliar application as compared to control.

2.5.6 Seed recovery percentage

Munde (2003) reported that soybean genotype JS-335 screened with 4 mm screen size was recorded maximum seed recovery percentage (99.85) to that of MACS-13 (99.84), MACS-24 (99.50) and MACS –58 (99.82).

2.5.7 Seed quality parameters

Raj *et al.* (2002) screened 28 soybean cultivars for seed mycoflora and observed *Aspergillus flavus, Aspergillus niger,* and *Alternaria alternata* were found predominant.

CHAPTER IV

RESULTS

Laboratory and field experiments were conducted with three soybean genotypes imposing different seed treatments. The data obtained in laboratory and field conditions were analysed and interpretation of the results are furnished with the following headings

4.1 STORABILITY STUDIES

4.1.1 Germination percentage

Irrespective of genotypes, treatments and containers the germination percentage gradually decreased with increase in period of storage and shown above certification standard (70%) even after six months of storage in all the genotypes (Table 1a,b,c,d). JS-335 recorded significantly higher germination than LSB-3 and MACS-450. Seeds stored in polylined cloth bag had more germination than cloth bag storage. The decline in germination over initial storage were high in cloth bag (12%) as that of polylined cloth bag storage (2%). Seed treatments gave significant impact for improving the germination over control. Among the seed treatments thiram followed by thiram+carbendazim recorded higher germination and significantly superior to bioagent seed treatments. Among bioagents *T. viride* recorded higher germination as compared to *T. harzianum*, *P. fluorescens* and *B. subtilis*. The decrease in germination from initial storage to six months were 8.7, 8.1, 7.8, 7.6, 5.1, 5.7, 9.0 per cent with *B.subtilis*, *P.fluorescens*, *T.viride*, *T.harzianum*, thiram, thiram + carbendazim and control, respectively. Irrespective of genotypes seeds stored in polylined cloth bag had higher germination than cloth bag storage particularly in JS-335. Seed treatments especially thiram or thiram+carbendazim were found effective for improving the germination over control in all the genotypes. Treated seed stored in polylined cloth bag was effective for increasing the germination over untreated seed stored in cloth bag. JS–335 seeds treated with thiram or thiram+carbendazim had maximum germination. Untreated LSB-3 seed stored in cloth bag shown minimum germination.

4.1.2 Seedling vigour

Seedling vigour index gradually decreased with period of storage in all the genotypes as well as containers and seed treatments. JS-335 had maximum seedling vigour index and significantly superior to LSB-3 and MACS-450 at all storage periods. Seed stored in polylined cloth bag showed higher seedling vigour index than cloth bag in all the genotypes especially in JS-335. Irrespective of genotypes seed treatments particularly thiram or thiram+carbendazim were effective for increasing seedling vigour index over control. Among bioagents *T. viride* was superior to other bioagent treatments and control. Such additional increase was high in JS-335 with seed treatments. Irrespective of seed treatments seed stored in polylined cloth bag had significantly higher seedling vigour index over cloth bag. Such increase was high with thiram or thiram + carbendazim. JS-335 seeds treated with thiram or thiram + carbendazim recorded maximum seedling vigour index (Table 2a,b,c,d) while untreated seed of LSB-3 stored in cloth bag had minimum seedling vigour index.

4.1.3 Seed moisture content

Fluctuation in moisture content of seed was high in cloth bag storage as that of polylined cloth bag in all the genotypes and seed treatments. Polylined cloth bag recorded lesser moisture content in all the genotypes (Table 3a,b,c,d). There was no significant difference with seed treatments, varieties, containers and their interaction effect on moisture content of seed.

4.1.4 Total fungal colonies (TFC)

Irrespective of genotypes, treatments and containers the total number of fungal colonies gradually increased with increase in period of storage. JS-335 recorded significantly less number of fungal colonies than LSB-3 and MACS-450. Seeds packed in polylined cloth bag had lesser fungal colonies than cloth bag storage (Plate 3). The increase in total number of fungal colonies over initial storage were high in cloth bag storage (13.59%) as that of polylined cloth bag storage (6.99%). Seed treatments especially with thiram or thiram+carbendazim recorded lesser number of fungal colonies as compared to untreated seed in all the genotypes (Table 4a,b,c,d). Among the bioagents *T. viride* was effective in reduction of total fungal colonies. Such response was high in JS-335. Treated seed stored in polylined cloth bag had less number of fungal colonies when compared with untreated seed stored in cloth bag.

JS-335 treated with thiram or thiram + carbendazim and stored in polylined cloth bag showed minimum fungal colonies (9.25%) and untreated seed of LSB-3 stored in cloth bag showed maximum fungal colonies (39.5%). Irrespective of genotypes the following fungal flora *Aspergillus flavus, Aspergillus niger, Rhizopus sp., Penicillium sp., Fusarium moniliforme, Curvularia lunata, Cercospora kikuchi, Alternaria alternate* were recorded during the period of storage.

4.1.5 Electrical conductivity

Electrical conductivity of seed leachates gradually increased with increase in period of storage. EC of seed leachates was more in cloth bag than polylined cloth bag in all the genotypes. There was reduction of EC of seed leachates with seed treatments (Table 5a,b,c,d) as compared to control. Minimum EC of seed leachates was observed in thiram followed by thiram+carbendazim. Such response was shown in all the genotypes particularly in JS-335. Seeds treated with thiram or thiram + carbendazim and stored in polylined cloth bag recorded minimum EC of seed leachates in JS-335. Maximum EC of seed leachates was observed in untreated seed of LSB-3 which was stored in cloth bag.

4.2 FIELD STUDIES

4.2.1 Field emergence index

Significant variations among the seed treatments were observed in respect of field emergence (Table 6). However such significant variations were not observed due to varieties and interaction between varieties and seed treatments (Fig. 1). Untreated seeds recorded minimum field emergence index (44.2) and significantly inferior to bioagents and fungicidal seed treatments. Among the seed treatments thiram (59.8) followed by thiram + carbendazim (61.5) were found effective for improving the field emergence over control (44.2) as well as bioagent seed treatments of *T. viride* (57.4), *T.harzianum* (55.1) *B. subtilis* (47.5) and *P. fluorescens* (49.0). Among the bioagents *T. viride* and *T. harzianum* were superior in improving the field emergence over bacterial bioagents of *B. subtillis* and *P. fluorescens* respectively.

4.2.2 Seedling mortality

Seedling mortality was significantly higher in control than all other seed treatments (Table 7, Fig. 2 and Plate 4). Among seed treatments thiram recorded the lowest seedling mortality (8.57%) followed by thiram + carbendazim (9.47%). Among bioagents *T. viride* (11.5%), *T. harzianum* (12.4%) recorded less seedling mortality over bacterial bioagents of *B. subtilis* (15.54%) and P. *fluorescens* (14.63%) over untreated control (22.6%). However there were no significant differences due to varieties and interaction between varieties and treatments. The seedling mortality was incited due to attack of seed borne pathogens viz., *Macrophomina phaseolina, Phytophthora sps, Aspergillus sps, Fusarium sps* and *Colletotrichum sps,* respectively.

4.2.3 Disease incidence

Disease incidence increased with the crop growth in all the varieties and treatments. Significant variation between varieties, seed treatments were observed in respect of disease incidence (Plate 5 and 6). However significant differences due to interaction between varieties and treatments were observed at 75 DAS only. LSB-3 recorded maximum disease incidence (16%) and significantly higher than JS-335 (13.5%) and MACS-450 (14.7%) at 75 DAS. Disease incidence decreased over control with seed treatments at all stages of the crop growth. At 75 DAS seed treatment with thiram (10.2%), thiram + carbendazim (10.8%) were effective in reducing disease incidence followed by bioagents *T. viride* (12.6%), *T. harzianum* (13.3%), *P. fluorescens* (16.7%) and *B.subtillis* (18.0%). The interaction effect between varieties and treatments in respect of disease incidence was observed at 75 DAS only. Untreated seeds recorded maximum incidence of disease (21.3%) in all the soybean genotypes. Irrespective of genotypes thiram (10.2%) followed by thiram + carbendazim (10.8%) recorded less disease incidence. Such increase was high in JS-335 (Table 8a,b). Irrespective of genotypes the following diseases Macrophomina root rot (*Alternaria alternata*), Anthracnose (*Macrophomina phaseolina*), Purple seed stain (*Cercospora kikuchi*), Soybean mosaic virus (SMV), leaf crinkle virus (LCV), yellow mosaic virus (YMV) and peanut bud necrosis virus (PBNV) were observed.

4.2.4 Plant height

Plant height was not differed significantly due to varieties, treatments and their interaction at all stages of crop growth (Table 9).

4.2.5 Total dry matter production

Total dry matter production per plant was significantly differed due to varieties, treatments and their interaction. JS-335 had maximum dry matter production per plant (17.80) when compared with LSB-3 (14.80) and MACS-450 (16.11). Seed treatments especially thiram (18.87) or thiram + carbendazim (17.51) were very effective for improving dry matter production over control (14.16). Thiram and thiram + carbendazim (Table 10) treatments were on par with each other in respect of dry weight of plant. Bioagents were also recorded higher dry matter production over control. Among bioagents *T. viride* was found effective for improving the dry matter production per plant. Irrespective of varieties seed treatments recorded higher dry matter production per plant over control. JS-335 seeds treated with thiram or thiram + carbendazim (20.67) gave maximum dry weight of plant. LSB-3 untreated seed had minimum dry weight of plant. The values of other interactions were in between these two extremes (Fig. 3).

4.2.6 Number of plants per plot

Seed treatments had significant influence on plant stand when compared with control. Thiram or thiram+carbendazim (200 plants) were on par with each other in recording plant population/plot (Table 11 and Fig. 4). These two treatments were significantly superior to bioagent treatments of. *T. viride* (193 plants), *T. harzianum* (187 plants) *P. fluorescens* (174) and *B. subtilis* (168 plants) per plot. The interaction effect between varieties and seed treatments were not observed in respect of plant stand.

4.2.7 Number of seeds per pod

A significant variation in number of seeds per pod among the genotypes was not observed. However significant variation for this character was observed due to seed treatments (Table 12). Seed treatment with thiram (2.49), thiram+carbendazim (2.43) had more number of seeds per pod which were significantly superior over control (2.37) as well as *T. viride* (2.41), *T. harzianum* (2.40), *P. fluorescens* (2.40) and *B. subtillis* (2.37). Control plots recorded (2.38) seeds per pod and it was on par with *B. subtilis*, *P. fluorescens*, *T. harzianum* and *T. viride*. Interaction effect was not observed due to varieties and seed treatments.

4.2.8 Number of seeds per plant

JS-335 recorded maximum number of seeds per plant (78.7) which was on par with MACS-450 (76.6). These two varieties were significantly superior to LSB-3 (69.5). Control plot recorded lowest number of seeds per plant (64.0) and significantly inferior to seed treatments. Thiram recorded maximum number of seeds per plant (87.2) followed by thiram + carbendazim (81.5) which were significantly superior to *T. viride* (78.0), *T. harzianum* (74.2), *P. fluorescens* (71.1) and *B. subtilis* (68.4). The increase in number of seeds per plant over control was 4.4, 7.1, 10.2, 14.0, 23.2 and 17.5 with *B. subtilis*, *P. fluorescens*, *T. harzianum*, *T. viride*, thiram and thiram + carbendazim, respectively. Irrespective of genotypes, seed treatments were found effective in increasing the number of seed per plant over control. Such increases in number of seeds per plant due to treatments were high in JS-335 than MACS-450 and LSB-3. The response of seed treatments particularly thiram or thiram+carbendazim were found very effective (Table 12). The increase in number of seeds per plant over control with *B. subtilis*, *P. fluorescens, T. harzianum*, *T. viride*, thiram and thiram+carbendazim were 9, 6.2, 6.3, 8.2, 16.4, 11.7, in LSB-3, 0.2, 5.4, 12.7, 16.8, 24.7, 21.2 in JS-335 and 9.5, 9.4, 9.7, 18.6, 28.5, 6.1, 13.4 respectively in MACS-450.

4.2.9 Hundred seed weight

Hundred seed weight was differed due to genotypes. 100 seed weight was high in JS-335 (12.29g) as against MACS-450 (11.87g) and LSB-3 (11.65g). Seed weight was significantly increased in seed treatments (Table 12) with *B. subtilis* (11.89g), *P. fluorescens* (11.81g), *T. harzianum* (11.98g), *T. viride* (11.98g), thiram (12.23g) and thiram+carbendazim (12.11g) as against control (11.57g).

4.2.10 Seed yield per plant (g)

JS-335 recorded maximum yield (9.69 g) per plant that was significantly superior to MACS-450 (9.11 g) and LSB-3 (8.11g). Seed treatments gave significantly higher yield over control (7.41g). Thiram (10.69g) followed by thiram+carbendazim (9.93g) recorded maximum yield which were significantly superior to other treatments of *B. subtilis* (8.13g), *P.fluorescens* (8.40g), *T. harzianum* (8.9g) *T. viride* (9.37g). Among bioagents *T. viride* was found effective for obtaining higher yield. The interaction between varieties and seed treatments was found significant in respect of yield per plant. Seed treatments particularly thiram or thiram + carbendazim were found effective in obtaining higher yield in all the genotypes. Such improvement in the yield due to treatments was high in JS-335 as against MACS-450 and LSB-3. The per cent increase in yield over control with *B. subtilis*, *P. fluorescens*, *T. harzianum, T.viride*, thiram and thiram+carbendazim were 16.23, 10.63, 17.52, 13.21, 32.90 and 23.70 in LSB-3, 8.1, 16.4, 28.8, 36.2, 55.0 and 44.7 in JS-335 and 5.65, 11.97, 14.07, 28.94, 48.68 and 31.52 in MACS-450 (Table 12 and Fig. 5).

4.2.11 Yield per hectare (Kg)

JS-335 recorded maximum yield per hectare (1521 kg) and it was significantly superior to MACS-450 (1404 kg) and LSB-3 (1231 kg). There was a significant improvement in yield per hectare (Table 12 and Fig. 6) in the seed treatments of thiram (1789 kg), thiram + carbendazim (1653 kg), *T. viride* (1513 kg), *T. harzianum* (1390 kg), *P. fluorescens* (1223 kg), *B. subtilis* (1143 kg) when compared to control (987 kg). Among seed treatments thiram, thiram + carbendazim were found very effective than other treatments. Among bioagents *T. viride* was effective for obtaining higher yield. The per cent improvement in yield over control were 156, 236, 403, 526, 802 and 666 kgs ha^{-1} with *B. subtilis*, *P. fluorescens*, *T.harzianum*, *T.viride*, thiram and thiram+carbendazim, respectively. Irrespective of genotypes, seed treatments particularly thiram, thiram + carbendazim were found effective in all the varieties. Such increase was very high in JS-335. The improvement in yield per ha over control with *B. subtilis*, *P. fluorescens*, *T. harzianum*, *T. viride*, thiram and thiram + carbendazim were 209, 203, 342, 346, 616, 508 kgs in LSB-3, 142, 279, 524, 668, 941, 836 in JS-335 and 117, 226, 340, 569, 851, 655 kgs in MACS-450.

4.2.12 Seed recovery percentage

The seed recovery percentage was high with seed treatment when compared with control in all the soybean genotypes. Thiram or thiram + carbendazim were very effective for obtaining high recovery percentage particularly in JS-335 (Table 13).

4.3 SEED QUALITY PARAMETERS OF THE HARVESTED PRODUCE

4.3.1 Germination percentage

The germination percentage was increased with seed treatments particularly thiram or thiram + carbendazim over control. JS-335 had maximum germination and significantly superior over MACS-450 and LSB-3 (Table 14). Among bioagents *T. viride, T. harzianum* were found superior in increasing germination. The interaction effect between varieties and treatments were not observed in respect of genotypes.

4.3.2 Seedling vigour

Seedling vigour index increased with seed treatments particularly in thiram (7049), thiram+carbendazim (6902) over control. Seedling vigour index was significantly superior in seed treatments as compared to control. Maximum (7049) and minimum (6407) seedling vigour index was recorded with thiram and untreated seed respectively (Table 14).

4.3.3 Seed mycoflora

LSB-3 had maximum number of total fungal colonies (9.5%) and significantly higher than JS-335 (7.38%) and MACS-450 (8.82%). Total fungal colonies were reduced with seed treatments of thiram (4.32%), thiram+carbendazim (5.58 %),

T viride (8.27 %), *T. harzianum* (8.27 %), *P. fluorescens* (10.26 %) and *B. subtilis* (10.73 %) as against control (12.23 %). Least number of fungal colonies were observed in thiram and found superior to other treatments. Among bioagents *T. viride* had less number of fungal colonies than other bioagents. The interaction effect was not observed due to varieties and treatments (Table 14).

CHAPTER V

DISCUSSION

Soybean the “Golden bean” is an important oil seed and pulse crop and the most likely solution for overcoming the world’s protein hunger. One of the major limitation in soybean production is the availability of quality seed at the time of planting. Losses due to seed borne diseases are estimated to the tune of 12 per cent of the total production. Since soybean seed is generally short lived, maintenance of seed viability and vigour from harvest till the next growing season during storage is one of the important criteria. The seed longevity is influenced by the genotype, moisture content, temperature, humidity and seed microflora which are responsible for poor germination and reduced plant stand. The type of storage container and seed treatments with various fungicides play an important role in maintaining viability of soybean seed (Zote and Maye, 1982) and reducing electrical conductivity of seed leachates. Leaching of electrolytes have often been associated with seed vigour, viability and some times with field emergence. Seed treatment with bioagents and fungicides are used to reduce seed borne fungi that cause seedling blight, seed decay and other diseases. Such treatments also protect the germinating seeds from the attack of certain soil inhibiting fungi. The results obtained in this present investigation is briefly discussed under the following headings.

5.1 EFFECT OF SEED TREATMENTS AND CONTAINERS ON STORABILITY

5.1.1 Germination percentage, seedling vigour

The germination percentage, seedling vigour and storability were high with seed treatments particularly thiram, thiram + carbendazim followed by *Trichoderma viride* when compared with control in three soybean genotypes. The effectiveness of seed treatments with thiram, thiram + carbendazim in maintaining good viability has been reported by Savitri *et al*. (1998), Solanke *et al*. (1998), Anuja *et al*. (2000) and Meena Kumari *et al*. (2002). The beneficial effect of seed treatment with seed dressing fungicides in minimizing loss in viability is in accordance with Kalavathi *et al*. (2000). The impact of bioagent *T.viride* in improving storability in hybrid rice was reported by Jeevalatha (2004). The present findings also confirm the above finding by using *T.viride* in improving the storability of soybean genotypes. Similar variation in seed storability results has been reported by Banumurthy and Gupta (1981), Vanangamudi (1988), Kuo (1989) and Pushpendra and Kamendra Singh (2002). As the storage period progressed there was a general decline in germination in different treatments in three soybean genotypes which could be attributed to irreversible phenomenon of ageing characteristics of all living organisms causing deteriorative changes in physical, physiological and biological condition of the seed (Abdul Baki and Anderson, 1972).

Gradual reduction in seedling vigour with increase in storage period in case of soybean was reported earlier by Meena Kumari *et al*. (2002).

5.1.2 Seed mycoflora

The per cent total fungal colonies gradually increased with the period of storage in all the genotypes with different seed treatments and containers. A significant variation was observed in total fungal colonies due to genotypes. LSB-3 recorded maximum number of total fungal colonies as compared to JS-335 and MACS-450. Irrespective of genotypes seed treatment with fungicides and biogents exerted a significant influence on total fungal colonies of three soybean genotypes when stored for the period of 6 months. In general there was an increase in the total number of fungal colonies with the advancement of storage period. Among the seed treatments thiram, thiram + carbendazim were most effective followed by *T.viride* which recorded less number of fungal colonies during the entire period of storage when compared with control. Such impact was high with JS-335. Seed treated with fungicides and stored in vapour proof container exhibited less number of fungal colonies than those of cloth bag storage in all the genotypes. Seed treatment with thiram, thiram + carbendazim, *T.viride* and stored in polylined cloth bag were found effective in reducing total number of fungal colonies in three soybean genotypes. The reduction in total number of fungal colonies with seed treatments might be due to the inhibition of seed borne pathogen and thus preventing seed deterioration and loss of membrane integrity. Similar findings were reported by Ravi Kumar *et al*. (1987), Singh *et al*. (1988), Charjan and Tarar (1992), Anuja *et al.* (2001) and Meena Kumari *et al.* (2002).

5.1.3 Electrical conductivity of seed leachates

Irrespective of genotypes untreated seed recorded higher EC of seed leachates than seeds treated with fungicides and bioagents. Seeds packed in vapour proof containers had lesser EC of seed leachates as compared to that of cloth bag storage. It clearly indicates that loss of membrane integrity which is one of the early symptoms of seed ageing was faster in seeds packed in moisture pervious container (cloth bag). Moisture proof container (polylined cloth bag) prevents the seed deterioration by seed borne mycoflora because of non fluctuation of moisture content of seed, maintenance of high membrane integrity, acts as a barrier for air borne mycoflora, reduces lipid peroxidation and prevents release of free radicals. Similar findings were made by Singh and Dadlani (2003).

5.2 FIELD STUDIES

5.2.1 Field emergence index

All seed treatments (bioagents and fungicides) recorded significantly higher field emergence rate than untreated control. This might be due to suppression of the activity of soil borne pathogens which facilitates the emergence and establishment of healthy seedlings. Similar findings were confirmed by Sundaresh and Hiremath (1982), Singh and Agarwal (1988), Kawale *et al*. (1989), Tripathi and Singh (1991), Chung and Ju (1993), Anuja *et al.* (2000) and Raj *et al.* (2002). Among the fungicides thiram, thiram + carbendazim were found effective in improving field emergence. Thiram, thiram + carbendazim controls most of the soil borne pathogen / fungi by seed treatment and improves germination vigour and field emergence. Similar assessment was made by Anuja *et al*. (2000) and Raj *et al*. (2002). Among the bioagents *T.viride* showed higher field emergence with minimum activity of pathogen subsequently enhances seed germination. It could be attributed to the production of not only anti fungal compounds but also growth regulating chytinolytic enzymes like glucanase and protease there by reducing pathogenic activity. Similar assessment was made by Krishnamurthy *et al.* (2003) in pulses.

5.2.2 Seedling mortality and seed borne diseases

Among soybean genotypes LSB-3 recorded maximum occurrence of diseases (16%) followed by JS 335 (13%) and MACS-450 (14.5%). The variation among the genotypes might be due to genotypic factor. Similar variation in disease incidence of different soybean genotypes were confirmed by Singh (1997), Meena Kumari *et al.* (2002) and Vrataric (2002).

Seed treatments particularly thiram, thiram + carbendazim recorded less mortality of seedlings and incidence of seed borne diseases. Fungicide treated seed controlled the external as well as internal seed borne pathogen and there by acts as protective coating to prevent soil borne pathogens from seedling infection. Similar observations were reported by Hall and Xue (1995), Das and Dutta (1999) and Gaulart *et al.* (2000). Seed treatment with fungicides is essential because when the seed germinates a larger number of pathogens carried with seed become active and cause either seed or seedling mortality or produce disease at later stages. The purpose of seed treatments by the use of fungicides is to destroy seed borne fungi that cause seedling blight, seedling decay, root rot and other diseases. Such treatments also protect the germinating seed against certain soil inhibiting fungi.

5.2.3 Total dry matter production (TDMP)

Irrespective of varieties seed treatment with fungicides and bioagents had profound influence in increasing dry weight of the plant in all the genotypes as compared with untreated seed. The increase in dry weight was due to more leaf area, higher plant height, more number of pods per plant, more number of seeds per plant with less incidence of disease. Number of plants in control was less when compared to seed treatments. It might be explained due to seedling mortality and more incidence of diseases at later stages. Similar findings were reported by Negalur *et al.* (2001).

5.2.4 Yield components and yield

Number of pods per plant, number of seeds per plant, seed weight, yield per plant, yield per ha were high in seed treatments with fungicides and bioagents as compared with untreated seed control. Such additional increase was high with thiram, thiram + carbendazim and *T.viride.* The increased yield was attributed to increase in plant stand and plant establishment with suppression of seed borne pathogens. Inhibition of the activity of pathogen resulted in more total dry matter production which facilitates more availability of photosynthates for sink and ultimately resulted in more number of seeds per pod, seed weight and thus increase in yield. Similar findings were observed by Singh and Agarwal (1988), Kawale *et al*. (1989), Thombre *et al*. (1989), Tripathi and Singh (1991), Anuja *et al*. (2000), Taywede *et al*. (2002) and Rajende-pm-de (2003).

- ❖ Present investigation clearly indicates that seed treated with thiram or thiram + carbendazim were very effective for improving the crop productivity by suppression of seedling mortality and seed borne pathogens *Alternaria alternata*, *Macrophomina phaseolina*, *Cercospora kikuchi*, Soybean mosaic virus (SMV), leaf crinkle virus (LCV), yellow mosaic virus (YMV) and peanut bud necrosis virus (PBNV) and these treatments were useful to farmers and seed industry personals for enhancing productivity of the crop.
- ❖ Soybean seeds packed in vapour proof container was very effective for extending the seed longevity and maintaining good seed storability by safe guarding seed deteriorating fungal flora.

CHAPTER VI

SUMMARY

The present investigation was taken up with three soybean genotypes (LSB-3, JS-335 and MACS-450), seed treatments with bioagents (*Trichoderma harzianum, Trichoderma viride, Bacillus substillis* and *Pseudomones fluorescens*), fungicides (thiram, thiram + carbendazim) and two containers (cloth bag, polylined cloth bag) for storability and field performance studies during *rabi* 2003. The results of the present investigation are summarised below.

Under laboratory conditions the germination percentage, seedling vigour and storability were increased with seed treatments particularly thiram, thiram + carbendazim followed by *T.viride* as compared with untreated control. Seeds packed in vapour proof containers had higher germination, seedling vigour and storability at all periods of storage in three soybean genotypes. Seeds treated with fungicides and stored in vapour proof container (Polylined cloth bag) exhibited lesser number of fungal colonies and lesser EC of seed leachates than cloth bag storage in all the genotypes. Seed treatment with thiram, thiram + carbendazim and *T.viride* and stored in polylined cloth bag were effective for reduction of total fungal colonies and leakage of electrolytes in all the soybean genotypes.

Under field evaluation trials field emergence index was high with seed treatments and bioagents against control plot. Seedling mortality and disease incidence was very low in seeds treated with thiram or thiram + carbendazim. Among bioagents *T.viride,* exhibited superior in reducing seedling mortality and disease incidence in all genotypes.

Total dry matter production, number of seeds per pod, number of seeds per plant, plant stand, 100 seed weight, seed recovery percentage, seed yield per plant, seed yield per ha were increased with seed treatments over control in all the soybean genotypes. Such additional increase was high with thiram, thiram + carbendazim and *T.viride*. The per cent increase in yield with *B. substillis, P. fluorescens, T. harzianum, T.viride*, thiram and thiram + carbendazim were 15.8, 23.8, 40.7, 53.2, 81.2 and 67.4 respectively over untreated control.

The following conclusions have been drawn from the investigation are as follows.

- Seed treatments found effective for improving the field emergence, germination, seedling vigour and storability as a result of low seedling mortality and lesser disease incidence.
- Bio-agents especially T.viride had significant role in maintenance of seed quality, storability, higher yields under field conditions.
- Thiram, thiram + carbendazim improved total dry matter production of the plant, yield and its components.

- It is recommended that either thiram, thiram + carbendazim were effective for obtaining higher yields by suppression of seed borne pathogens at various stages of the crop growth and thus maintaining healthy crop. Bioagent *T.viride* was also similarly effective for the above traits over other bioagents. However *T.viride* is inferior to fungicides seed treatments in respect of seed quality, storability and yield.

Contd.. 1d (V x T x C)

	Two months									Four months									Six months								
	V_1			V_2			V_3			V_1			V_2			V_3			V_1			V_2			V_3		
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean
T_1	84.0 (66.4)	87.3 (69.1)	85.6 (67.7)	84.5 (66.8)	86.5 (68.4)	85.5 (67.6)	83.0 (65.6)	83.4 (65.9)	83.2 (65.8)	81.0 (64.2)	81.9 (64.8)	81.4 (64.5)	86.4 (68.3)	87.0 (68.8)	86.7 (68.6)	85.5 (67.7)	86.0 (68.0)	85.7 (67.8)	69.0 (56.1)	80.0 (63.4)	74.5 (59.8)	76.9 (61.2)	84.5 (66.8)	80.7 (64.0)	75.0 (60.0)	84.0 (66.4)	79.5 (63.2)
T_2	85.0 (67.2)	87.6 (69.4)	86.3 (68.3)	85.0 (67.2)	88.1 (69.9)	86.5 (68.5)	84.0 (66.1)	85.0 (67.2)	84.5 (66.8)	81.0 (64.2)	85.1 (67.3)	83.0 (65.7)	87.8 (91.5)	88.5 (70.0)	88.1 (69.8)	86.2 (68.2)	87.5 (69.3)	86.0 (68.8)	70.0 (56.7)	80.5 (63.8)	75.2 (60.3)	77.5 (61.6)	86.0 (68.0)	81.7 (64.8)	76.0 (60.6)	85.2 (67.4)	80.6 (64.0)
T_3	89.0 (70.6)	88.2 (69.9)	88.6 (70.3)	88.5 (70.1)	90.0 (71.5)	89.2 (70.8)	85.5 (67.6)	86.7 (68.6)	86.1 (68.1)	82.9 (65.5)	85.6 (67.7)	84.3 (66.6)	91.5 (73.0)	91.0 (72.5)	91.2 (72.8)	88.5 (70.1)	88.5 (70.1)	88.5 (70.1)	72.0 (58.0)	81.6 (64.6)	76.8 (61.3)	80.2 (63.5)	88.9 (70.6)	84.5 (67.0)	76.5 (61.0)	88.0 (69.7)	82.2 (65.4)
T_4	89.5 (71.0)	88.8 (70.4)	89.1 (70.7)	87.4 (69.4)	90.7 (72.3)	89.0 (70.8)	86.0 (68.1)	87.5 (69.3)	86.7 (68.6)	83.9 (66.3)	86.1 (58.1)	85.0 (67.2)	92.0 (73.5)	93.0 (74.6)	92.5 (74.1)	92.3 (73.9)	90.5 (72.0)	90.2 (71.8)	74.0 (59.3)	81.9 (64.8)	77.9 (62.0)	81.5 (64.5)	90.0 (71.5)	85.7 (68.0)	76.9 (61.1)	90.0 (71.6)	83.5 (66.4)
T_5	90.0 (71.5)	93.5 (75.2)	91.7 (73.4)	90.3 (72.8)	92.5 (74.1)	91.9 (73.4)	90.0 (71.5)	90.5 (72.0)	90.2 (71.8)	86.5 (68.4)	90.3 (71.8)	88.4 (70.0)	94.5 (76.4)	95.0 (77.0)	94.7 (76.1)	91.0 (72.5)	92.7 (74.7)	92.5 (74.1)	77.5 (61.8)	86.7 (68.6)	82.1 (65.1)	87.0 (68.8)	92.5 (74.1)	89.7 (71.5)	83.3 (65.9)	90.0 (71.6)	86.6 (68.7)
T_6	88.0 (69.7)	92.2 (73.8)	90.1 (71.7)	98.3 (71.8)	92.0 (73.5)	91.1 (72.7)	89.0 (70.6)	89.5 (71.1)	89.2 (70.8)	85.2 (67.4)	90.0 (71.6)	87.6 (69.5)	93.0 (74.6)	93.0 (74.7)	93.0 (74.6)	83.0 (65.6)	92.0 (73.5)	91.5 (73.0)	76.0 (60.6)	85.4 (67.5)	80.7 (64.1)	85.0 (67.2)	91.0 (72.5)	88.0 (69.8)	83.5 (66.0)	89.5 (71.0)	86.6 (68.5)
T_7	83.0 (65.6)	87.3 (69.1)	85.5 (67.3)	80.0 (63.4)	86.8 (68.7)	83.4 (66.0)	81.0 (64.1)	81.6 (64.6)	81.3 (64.3)	80.0 (63.4)	83.8 (66.2)	81.9 (64.8)	83.9 (66.4)	87.5 (69.3)	85.7 (67.6)	88.0 (69.9)	83.7 (66.2)	83.3 (65.9)	67.2 (55.0)	79.9 (63.4)	73.6 (59.2)	75.0 (60.0)	86.0 (68.0)	80.5 (64.0)	74.5 (59.6)	80.0 (63.4)	77.2 (61.5)
Mean	86.9 (68.9)	89.2 (70.0)	83.2 (65.8)	86.7 (68.8)	89.5 (71.2)		85.5 (67.7)	86.3 (68.4)		82.9 (65.6)	86.0 (68.2)		89.8 (71.7)	90.7 (72.4)	85.7 (67.8)	86.0 (68.0)	88.7 (70.5)		72.2 (58.2)	82.3 (65.1)		80.4 (63.8)	88.4 (70.2)		77.9 (62.0)	88.6 (68.7)	

	Two months				Four months				Six months			
	Variety	Treatment	Container	Variety x Treatment x Container	Variety	Treatment	Container	Variety x Treatment x Container	Variety	Treatment	Container	Variety x Treatment x Container
SEm±	0.12	0.17	0.09	0.41	0.09	0.13	0.07	0.33	0.11	0.17	0.09	0.43
CD at 5 %	0.30	0.46	0.25	1.13	0.24	0.37	0.20	0.90	0.32	0.48	0.26	1.18

Figures in parentheses are angular transformed values

Treatments

T_1 – *Bacillus subtilis*
T_2 – *Pseudomonas fluorescens*
T_3 – *Trichoderma harzianum*
T_4 – *Trichoderma viride*
T_5 – Thiram
T_6 - Thiram + Carbendazim
T_7 – Control

Varieties

V_1 – LSB 3
V_2 – JS-335
V_3– MACS-450

Containers

C_1 – Cloth bag
C_2 – Polylined cloth bag

Contd.. 2d (V x T x C)

	Two months									Four months									Six months								
	V_1			V_2			V_3			V_1			V_2			V_3			V_1			V_2			V_3		
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean
T_1	5914	5788	5851	6378	6622	6500	6073	6137	6105	5661	5971	5816	6632	6702	6667	6307	6358	6333	4553	5579	5066	5477	6426	5951	5289	6165	5727
T_2	6635	6269	6452	6448	6737	6593	6198	6268	6233	5700	6069	5884	6757	6853	6805	6371	6492	6431	4655	5659	5157	5518	6553	6035	5336	6268	5802
T_3	6435	6322	6378	6820	6948	6884	6326	6446	6386	5967	6117	6042	7157	7117	7137	6583	6633	6689	5133	5662	5397	5802	6782	6292	5552	6599	6075
T_4	6533	6446	6489	6963	7037	7000	6385	6542	6463	6111	6243	6117	7186	7276	7231	6717	6802	6759	5328	5915	5621	5898	6869	6384	5660	6668	6164
T_5	6565	6793	6679	7043	7155	7099	6712	6732	6722	6344	6555	6449	7386	7426	7406	6942	6992	6967	5623	6272	5947	6351	7116	6734	6226	6678	6452
T_6	6344	6669	6506	7081	7055	7068	6619	6631	6625	5441	6496	5968	7168	7230	7199	6787	6872	6829	5398	6150	5773	6168	7983	6576	5933	6634	6283
T_7	5793	6111	5952	6426	6467	6446	5879	5867	5873	5560	5858	5709	6321	7338	6829	6066	6144	6105	4580	5579	5079	5326	6343	5834	5213	5798	5505
Mean	6317	6342		6737	6860		6313	6374		5826	6817		6944	7135		6539	6613		5038	5830		5791	6724		5601	6401	

	Two months				Four months				Six months			
	Variety	Treatment	Container	Variety x Treatment x Container	Variety	Treatment	Container	Variety x Treatment x Container	Variety	Treatment	Container	Variety x Treatment x Container
SEm±	3.21	4.90	2.62	12.00	30.73	31.62	25.09	115.00	2.60	3.97	2.12	9.74
CD at 5 %	8.90	13.5	7.26	33.30	85.19	30.14	69.56	318.70	7.20	11.0	5.89	27.00

Treatments

T_1 – *Bacillus subtilis*
T_2 – *Pseudomonas fluorescens*
T_3 – *Trichoderma harzianum*
T_4 – *Trichoderma viride*
T_5 – Thiram
T_6 - Thiram + Carbendazim
T_7 – Control

Varieties

V_1 – LSB 3
V_2 – JS-335
V_3 – MACS-450

Containers

C_1 – Cloth bag
C_2 – Polylined cloth bag

Contd.. 5d (V x T x C)

	Two months								
	V_1			V_2			V_3		
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean
T_1	1478	1369	1423	1130	1125	1127	1600	995	1297
T_2	1486	1369	1427	1059	1118	1089	1552	993	1272
T_3	1429	1367	1398	970	1000	985	1395	990	1192
T_4	1415	1368	1391	973	990	981	1385	988	1186
T_5	1376	1358	1367	950	980	965	1050	982	1016
T_6	1385	1361	1373	988	996	992	1110	984	1047
T_7	1540	1371	1455	1202	1250	1226	1582	998	1290
Mean	1440	1366		1039	1065		1382	990	

	Four months								
	V_1			V_2			V_3		
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean
T_1	2266	1766	2016	1349	1250	1299	1624	1240	1432
T_2	2258	1735	1996	1327	1275	1301	1573	1236	1404
T_3	2018	1687	1852	1260	1100	1180	1489	1153	1321
T_4	2005	1670	1837	1260	1150	1205	1447	1187	1317
T_5	1603	1452	1527	1020	1000	1010	1176	1066	1121
T_6	1700	1485	1592	1042	1010	1026	1192	1073	1132
T_7	2359	1800	2079	1387	1310	1349	1650	1287	1468
Mean	2029	1656		1235	1156		1450	1177	

	Six months								
	V_1			V_2			V_3		
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean
T_1	4523	2686	3604	2626	1928	2277	3330	1992	2646
T_2	4510	2649	3579	2550	1902	2249	3257	1973	2615
T_3	4514	2568	3541	2450	1921	2135	2958	1911	2434
T_4	4426	2514	3470	2427	1770	2098	3426	1870	2648
T_5	2784	2013	2398	1963	1518	1741	2257	1630	1944
T_6	2924	2087	2505	2000	1577	1788	2161	1655	2108
T_7	4524	2757	3640	2637	1916	2276	3310	2000	2655
Mean	4029	2467		2385	1776		3009	1862	

	Two months				Four months				Six months			
	Variety	Treatment	Container	Variety x Treatment x Container	Variety	Treatment	Container	Variety x Treatment x Container	Variety	Treatment	Container	Variety x Treatment x Container
SEm±	3.25	4.96	2.65	12.16	2.71	4.15	2.21	29.25	16.71	25.53	13.65	62.55
CD at 5 %	9.00	13.76	7.35	33.76	7.53	11.50	6.15	28.19	46.34	70.78	37.83	173.39

Treatments

T_1 – *Bacillus subtilis*
T_2 – *Pseudomonas fluorescens*
T_3 – *Trichoderma harzianum*
T_4 – *Trichoderma viride*
T_5 – Thiram
T_6 - Thiram + Carbendazim
T_7 – Control

Varieties

V_1 – LSB 3
V_2 – JS-335
V_3 – MACS-450

Containers

C_1 – Cloth bag
C_2 – Polylined cloth bag

Contd.. 4d (V x T x C)

Two months

	V_1			V_2			V_3		
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean
T_1	21.0 (27.2)	17.5 (24.7)	19.3 (26.0)	16.5 (23.9)	12.7 (20.8)	14.6 (22.4)	20.0 (26.5)	13.5 (21.5)	16.7 (24.0)
T_2	19.5 (26.2)	17.0 (24.3)	18.3 (25.3)	16.0 (23.5)	12.0 (20.2)	14.0 (21.9)	18.5 (25.4)	13.7 (21.7)	16.1 (23.6)
T_3	13.5 (21.5)	13.5 (21.5)	13.5 (21.5)	10.7 (19.1)	9.3 (17.7)	10.0 (18.4)	13.0 (21.3)	10.5 (18.9)	11.7 (20.2)
T_4	12.5 (20.7)	13.5 (21.5)	13.0 (21.1)	9.0 (17.4)	8.0 (16.4)	8.5 (16.9)	11.0 (19.3)	9.0 (17.4)	10.0 (18.4)
T_5	5.0 (12.9)	4.5 (10.7)	4.3 (11.8)	9.0 (17.4)	4.5 (12.2)	6.7 (14.8)	3.5 (12.2)	2.5 (9.0)	3.5 (10.6)
T_6	6.5 (14.7)	4.5 (12.2)	5.8 (13.5)	10.5 (8.9)	4.0 (11.1)	7.2 (15.0)	5.5 (13.6)	3.5 (9.8)	4.5 (12.9)
T_7	36.0 (36.8)	31.5 (33.9)	33.7 (35.4)	22.0 (27.9)	18.0 (25.1)	20.1 (26.5)	23.5 (28.9)	19.0 (25.8)	21.3 (27.4)
Mean	16.2 (22.9)	14.4 (21.3)		13.3 (21.2)	9.7 (17.6)		13.7 (21.0)	10.3 (17.9)	

Four months

	V_1			V_2			V_3		
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean
T_1	26.5 (30.5)	18.0 (25.1)	22.0 (27.8)	17.0 (24.3)	15.0 (22.7)	16.0 (23.5)	21.0 (27.2)	14.5 (22.4)	17.7 (24.8)
T_2	21.0 (27.2)	17.2 (24.5)	19.1 (25.9)	18.0 (25.1)	13.3 (21.3)	15.6 (23.2)	19.5 (26.2)	14.0 (21.9)	16.7 (24.0)
T_3	14.0 (21.9)	14.5 (22.3)	14.2 (22.1)	11.5 (19.8)	10.7 (19.1)	11.1 (19.4)	13.8 (21.8)	11.7 (20.0)	12.7 (21.0)
T_4	13.5 (21.5)	13.7 (21.7)	13.6 (21.6)	10.5 (18.9)	9.5 (17.9)	10.0 (18.4)	12.0 (20.6)	10.5 (18.5)	11.2 (19.5)
T_5	6.5 (14.8)	6.5 (14.7)	6.5 (14.7)	9.5 (17.9)	6.0 (14.1)	7.7 (16.0)	8.0 (16.4)	5.0 (12.9)	6.5 (14.6)
T_6	8.0 (16.4)	6.5 (14.7)	7.2 (15.5)	10.3 (18.6)	7.5 (16.0)	8.8 (17.2)	9.5 (7.9)	6.5 (14.7)	8.0 (16.3)
T_7	37.5 (37.6)	25.2 (30.1)	31.3 (33.9)	23.0 (28.6)	19.5 (26.2)	21.2 (27.4)	25.5 (30.2)	19.2 (26.0)	22.3 (28.1)
Mean	18.0 (24.3)	14.5 (21.9)		14.2 (21.9)	11.6 (19.6)		15.6 (22.8)	11.6 (19.5)	

Six months

	V_1			V_2			V_3		
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean
T_1	32.0 (34.4)	22.5 (28.3)	27.2 (31.3)	24.5 (29.6)	18.2 (25.2)	21.3 (27.4)	27.1 (31.3)	17.0 (24.3)	20.0 (27.8)
T_2	29.5 (32.8)	21.0 (27.2)	25.2 (30.0)	24.0 (29.3)	16.5 (23.9)	20.2 (26.6)	25.5 (30.9)	16.0 (24.0)	21.5 (27.5)
T_3	23.8 (29.2)	18.0 (25.1)	20.9 (27.1)	20.0 (26.5)	14.2 (22.1)	17.0 (24.3)	22.0 (27.9)	14.6 (22.4)	18.3 (25.2)
T_4	19.5 (26.2)	16.7 (24.1)	18.1 (25.1)	17.5 (24.7)	12.7 (20.8)	15.1 (22.8)	19.7 (26.3)	13.5 (21.4)	16.6 (23.9)
T_5	14.5 (22.3)	10.5 (18.9)	12.5 (20.6)	10.5 (18.9)	8.0 (16.4)	9.2 (17.6)	11.0 (19.3)	9.5 (17.9)	10.2 (18.6)
T_6	17.0 (24.3)	12.0 (20.2)	14.5 (22.3)	13.0 (21.1)	10.0 (18.4)	11.5 (19.7)	13.5 (21.5)	9.9 (18.4)	11.7 (19.9)
T_7	48.0 (43.8)	31.0 (33.8)	39.5 (38.8)	29.5 (32.8)	21.3 (27.5)	25.4 (30.2)	31.0 (33.8)	21.6 (27.7)	26.3 (30.7)
Mean	26.3 (30.4)	18.8 (25.4)		19.8 (26.1)	14.4 (22.1)		21.5 (27.3)	14.6 (22.3)	

	Two months				Four months				Six months			
	Variety	Treatment	Container	Variety x Treatment x Container	Variety	Treatment	Container	Variety x Treatment x Container	Variety	Treatment	Container	Variety x Treatment x Container
SEm$\pm$	0.15	0.22	0.12	0.55	0.08	0.13	0.07	0.32	0.02	0.04	0.02	0.09
CD at 5 %	0.40	0.62	0.33	1.51	0.23	0.36	0.19	0.88	0.07	0.05	0.05	0.24

Figures in parentheses are angular transformed values

Treatments

T_1 – *Bacillus subtilis*
T_2 – *Pseudomonas fluorescens*
T_3 – *Trichoderma harzianum*
T_4 – *Trichoderma viride*
T_5 – Thiram
T_6 - Thiram + Carbendazim
T_7 – Control

Varieties

V_1 – LSB 3
V_2 – JS-335
V_3 – MACS-450

Containers

C_1 – Cloth bag
C_2 – Polylined cloth bag

Contd.. 3d (V x T x C)

	Two months									Four months									Six months								
	V_1			V_2			V_3			V_1			V_2			V_3			V_1			V_2			V_3		
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean
T_1	12.9 (21.0)	8.1 (16.5)	10.5 (18.8)	12.8 (20.9)	8.1 (16.5)	10.4 (18.7)	12.7 (20.9)	8.0 (16.5)	10.4 (18.7)	12.3 (20.5)	8.1 (16.5)	10.2 (18.5)	11.6 (19.9)	8.1 (16.5)	9.8 (18.2)	12.0 (20.2)	8.2 (16.6)	10.0 (18.4)	12.9 (20.1)	8.4 (16.8)	10.7 (18.9)	13.0 (21.1)	8.2 (16.6)	10.6 (18.9)	12.8 (20.9)	8.2 (16.6)	10.5 (18.8)
T_2	12.9 (21.0)	8.1 (16.5)	10.5 (18.8)	12.7 (20.9)	8.1 (16.5)	10.4 (18.7)	12.7 (20.8)	8.1 (16.5)	10.4 (18.7)	12.3 (20.5)	8.2 (16.6)	10.2 (18.5)	11.7 (20.0)	8.2 (16.6)	9.9 (18.3)	12.1 (20.3)	8.1 (16.5)	10.1 (18.4)	12.9 (21.0)	8.4 (16.8)	10.6 (18.9)	12.8 (21.0)	8.2 (16.7)	10.5 (18.8)	12.7 (20.8)	8.3 (16.7)	10.5 (18.8)
T_3	12.7 (20.9)	8.1 (16.5)	10.4 (18.7)	12.6 (20.8)	8.1 (16.5)	10.3 (18.6)	12.6 (20.7)	8.1 (16.5)	10.3 (18.6)	12.2 (20.4)	8.2 (16.6)	10.2 (18.5)	11.6 (19.9)	8.1 (16.5)	9.8 (18.2)	11.9 (20.1)	8.1 (16.5)	10.0 (18.3)	12.8 (20.9)	8.3 (16.7)	10.5 (18.8)	12.8 (20.9)	8.3 (16.7)	10.5 (18.8)	12.6 (20.8)	8.3 (16.7)	10.4 (18.7)
T_4	12.7 (20.9)	8.1 (16.5)	10.4 (18.7)	12.8 (20.9)	8.0 (16.4)	10.4 (18.7)	12.5 (20.7)	8.0 (16.5)	10.3 (18.6)	12.2 (20.4)	8.1 (16.5)	10.2 (18.5)	11.8 (20.0)	8.1 (16.5)	9.9 (18.3)	11.7 (20.0)	8.0 (16.4)	9.9 (18.2)	12.9 (21.0)	8.3 (16.7)	10.5 (18.8)	12.7 (20.9)	8.2 (16.6)	10.4 (18.7)	12.7 (20.8)	8.2 (16.6)	10.4 (18.7)
T_5	12.7 (20.9)	8.1 (16.5)	10.4 (18.7)	12.6 (20.8)	8.1 (16.5)	10.3 (18.6)	12.6 (20.7)	8.0 (16.4)	10.3 (18.6)	12.1 (20.3)	8.3 (16.7)	10.2 (18.5)	11.5 (19.8)	8.1 (16.5)	9.8 (18.2)	11.8 (20.1)	8.1 (16.5)	10.0 (18.3)	12.8 (20.9)	8.2 (16.6)	10.5 (18.8)	12.8 (21.0)	8.2 (16.7)	10.5 (18.8)	12.6 (20.8)	8.2 (16.6)	10.4 (18.7)
T_6	12.7 (20.9)	8.1 (16.5)	10.4 (18.7)	12.6 (20.8)	8.1 (16.5)	10.3 (18.6)	12.5 (20.7)	8.1 (16.5)	10.3 (18.6)	12.1 (20.3)	8.2 (16.6)	10.1 (18.4)	11.6 (19.9)	8.1 (16.5)	9.8 (18.2)	11.9 (20.1)	8.1 (16.5)	10.0 (18.3)	12.8 (21.0)	8.2 (16.7)	10.5 (18.8)	12.8 (21.0)	8.2 (16.6)	10.5 (18.8)	12.7 (20.8)	8.2 (16.6)	10.4 (18.7)
T_7	13.1 (21.2)	8.2 (16.6)	10.69 (18.9)	12.7 (20.8)	8.1 (16.5)	10.4 (18.7)	12.8 (20.9)	8.1 (16.5)	10.4 (18.7)	12.5 (20.7)	8.2 (16.6)	10.3 (18.7)	11.6 (19.9)	8.2 (16.6)	9.9 (18.3)	11.9 (20.1)	8.2 (16.6)	10.0 (18.4)	13.1 (21.2)	8.4 (16.8)	10.7 (19.0)	13.0 (21.1)	8.3 (16.7)	10.6 (18.9)	12.9 (21.0)	8.3 (16.7)	10.6 (18.9
Mean	12.8 (25.0)	8.1 (16.5)		12.7 (20.8)	8.1 (16.5)		12.6 (20.8)	8.1 (16.5)		12.2 (20.4)	8.2 (16.6)		11.6 (19.9)	8.1 (16.5)		11.9 (20.1)	8.1 (16.5)		12.9 (21.0)	8.3 (16.7)		12.8 (21.0)	8.2 (16.7)		12.7 (21.0)	8.2 (16.6)	

	Two months				Four months				Six months			
	Variety	Treatment	Container	Variety x Treatment x Container	Variety	Treatment	Container	Variety x Treatment x Container	Variety	Treatment	Container	Variety x Treatment x Container
SEm±	0.16	0.01	0.01	0.04	0.01	0.02	0.01	0.04	0.01	0.01	0.01	0.03
CD at 5 %	0.04	0.03	0.02	0.11	0.03	0.05	0.02	0.11	0.10	0.03	0.02	NS

Figures in parentheses are angular transformed values

Treatments

T_1 – *Bacillus subtilis*
T_2 – *Pseudomonas fluorescens*
T_3 – *Trichoderma harzianum*
T_4 – *Trichoderma viride*
T_5 – Thiram
T_6 - Thiram + Carbendazim
T_7 – Control

Varieties

V_1 – LSB 3
V_2 – JS-335
V_3– MACS-450

Containers

C_1 – Cloth bag
C_2 – Polylined cloth bag

Table 4a : Effect of seed treatments and containers (T x C) on total fungal colonies at different periods of seed storage in soybean

	Initial after seed treatment				2 months				4 months				6 months			
	V_1	**V_2**	**V_3**	**Mean**	**V_1**	**V_2**	**V_3**	**Mean**	**V_1**	**V_2**	**V_3**	**Mean**	**V_1**	**V_2**	**V_3**	**Mean**
T_1	14.37 (22.27)	11.50 (19.82)	13.00 (21.13)	12.95 (12.10)	19.21 (26.00)	14.61 (22.43)	16.75 (24.06)	16.85 (24.06)	22.00 (27.84)	16.00 (23.56)	17.76 (24.83)	18.50 (25.42)	27.25 (31.38)	21.36 (27.47)	22.06 (27.86)	23.55 (28.50)
T_2	14.00 (21.97)	11.00 (19.36)	12.50 (20.70)	12.50 (20.70)	18.25 (25.27)	14.00 (21.92)	16.12 (23.62)	16.12 (23.62)	19.12 (25.90)	15.62 (23.22)	16.73 (24.08)	17.15 (24.15)	25.25 (30.08)	20.25 (26.65)	21.55 (27.56)	22.35 (27.95)
T_3	11.00 (19.36)	8.50 (16.95)	9.50 (17.95)	9.66 (18.00)	13.50 (21.55)	10.00 (18.42)	11.75 (20.02)	11.75 (20.20)	14.25 (22.17)	11.12 (19.48)	12.77 (20.92)	12.71 (20.91)	20.94 (27.18)	17.12 (24.30)	18.30 (25.22)	18.78 (25.60)
T_4	9.00 (17.45)	7.42 (15.81)	8.00 (16.42)	8.14 (16.50)	13.00 (21.12)	8.50 (16.94)	10.00 (18.41)	10.50 (19.10)	13.62 (21.66)	10.00 (18.42)	11.25 (19.58)	11.62 (19.65)	18.12 (25.18)	15.12 (22.82)	16.62 (23.97)	16.62 (23.17)
T_5	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	4.25 (11.84)	2.75 (14.85)	3.50 (10.67)	3.50 (10.67)	6.50 (14.76)	7.75 (16.06)	6.50 (14.67)	8.91 (17.35)	12.50 (20.64)	9.25 (17.66)	10.25 (18.66)	10.66 (18.75)
T_6	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	5.50 (13.50)	7.25 (15.02)	9.51 (12.19)	7.42 (15.25)	7.25 (15.59)	8.88 (17.28)	8.00 (16.35)	8.66 (17.18)	14.50 (22.30)	11.50 (19.78)	11.73 (19.98)	12.50 (20.64)
T_7	25.00 (29.99)	16.50 (23.96)	17.30 (24.72)	19.60 (26.50)	33.75 (35.42)	20.01 (26.54)	21.25 (27.41)	25.00 (30.00)	31.37 (33.94)	21.25 (27.43)	22.39 (28.18)	25.00 (30.01)	39.50 (38.84)	25.43 (30.21)	26.32 (30.71)	30.41 (35.43)
Mean	10.48 (18.85)	5.88 (14.21)	8.61 (17.10)		14.46 (22.15)	11.02 (19.20)	12.70 (20.90)		16.27 (23.78)	12.98 (21.30)	13.60 (21.65)		22.58 (28.35)	17.15 (24.50)	8.15 (25.10)	

	Initial after seed treatment			Two months				Four months				Six months			
				V	**T**	**V x T**		**V**	**T**	**V x T**		**V**	**T**	**V x T**	
SEm$\pm$				0.15	0.22	0.38		0.08	0.13	0.22		0.03	0.04	0.06	
CD at 5 %				0.41	0.62	1.07		0.23	0.35	0.62		0.09	0.09	NS	

Figures in parentheses are angular transformed values

V_1: LSB-3
V_2: JS-335
V_3: MACS-450

T_1: *Bacillus subtilis*
T_2: *Pseudomonas fluorescens* .
T_3: *Trichoderma harzianum*
T_4: *Trichoderma viride*

T_5: thiram
T_6: thiram+carbendazim
T_7: control

Table 1a : Effect of seed treatments and containers on seed germination at different periods of seed storage in soybean

	Initial after seed treatment				2 months				4 months				6 months			
	V_1	**V_2**	**V_3**	**Mean**	**V_1**	**V_2**	**V_3**	**Mean**	**V_1**	**V_2**	**V_3**	**Mean**	**V_1**	**V_2**	**V_3**	**Mean**
T_1	88.0 (69.7)	87.68 (69.45)	85.00 (67.20)	86.90 (68.75)	85.65 (67.77)	85.50 (67.63)	83.21 (65.81)	84.79 (66.78)	81.48 (64.52)	86.70 (68.61)	85.75 (67.82)	84.64 (67.18)	74.51 (59.81)	80.68 (64.03)	79.50 (63.21)	78.23 (62.85)
T_2	88.25 (69.95)	88.31 (70.00)	85.40 (67.60)	87.32 (69.35)	86.32 (68.32)	86.59 (68.55)	84.51 (66.83)	85.81 (67.91)	83.06 (65.73)	88.15 (69.86)	86.91 (68.80)	86.04 (68.08)	75.28 (60.31)	81.75 (64.85)	80.62 (64.06)	79.22 (64.52)
T_3	89.43 (71.03)	89.70 (71.30)	87.70 (69.52)	88.94 (70.94)	88.63 (70.30)	89.25 (70.87)	86.16 (68.17)	88.01 (69.70)	84.32 (66.69)	91.26 (72.80)	88.50 (70.19)	88.03 (69.70)	76.80 (61.32)	84.58 (67.09)	82.25 (65.40)	81.18 (64.25)
T_4	90.06 (71.62)	90.70 (72.20)	89.00 (70.64)	89.92 (71.37)	89.15 (70.77)	89.08 (70.86)	86.75 (68.67)	88.33 (70.15)	85.03 (67.25)	92.51 (74.12)	90.25 (71.83)	89.26 (71.05)	77.96 (62.09)	85.75 (68.04)	83.37 (66.40)	82.30 (65.83)
T_5	90.50 (72.06)	92.50 (74.10)	91.00 (72.56)	91.33 (72.75)	91.75 (73.40)	91.91 (73.49)	90.25 (71.83)	91.30 (72.96)	88.40 (70.15)	94.75 (76.76)	92.56 (74.19)	91.90 (73.02)	82.12 (65.17)	89.76 (71.50)	86.68 (68.79)	86.16 (68.25)
T_6	89.50 (71.00)	92.50 (74.11)	90.43 (71.99)	90.81 (72.25)	90.12 (71.78)	91.15 (72.71)	89.26 (70.80)	90.18 (71.85)	87.67 (69.54)	93.02 (74.68)	91.50 (73.07)	90.73 (69.95)	80.71 (64.11)	88.00 (69.88)	86.50 (68.50)	85.07 (67.25)
T_7	86.70 (68.65)	84.50 (66.80)	82.00 (64.90)	84.40 (66.70)	85.15 (67.38)	83.40 (66.07)	81.31 (64.39)	83.28 (65.86)	81.90 (64.85)	85.74 (67.85)	83.37 (65.95)	83.63 (66.20)	73.59 (59.24)	80.50 (64.01)	77.25 (61.55)	77.12 (61.35)
Mean	88.92 (71.35)	89.41 (71.05)	87.21 (68.90)		88.10 (69.75)	88.12 (69.82)	85.92 (67.95)		84.55 (67.05)	90.30 (69.35)	83.40 (69.95)		77.28 (61.40)	84.36 (66.65)	82.32 (65.80)	

	Initial after seed treatment			**Two months**				**Four months**				**Six months**			
				V	**T**	**V x T**		**V**	**T**	**V x T**		**V**	**T**	**V x T**	
SEm±				0.17	0.15	0.29		0.13	0.12	0.23		0.17	0.17	0.30	
at 5 %				0.46	0.43	0.80		0.37	0.17	0.33		0.48	0.26	0.43	

Figures in parentheses are angular transformed values

V_1: LSB-3
V_2: JS-335
V_3: MACS-450

T_1: *Bacillus subtilis*
T_2: *Pseudomonas fluorescens* .
T_3: *Trichoderma harzianum*
T_4: *Trichoderma viride*

T_5: thiram
T_6: thiram+carbendazim
T_7: control

Table 3a : Effect of seed treatments and containers on moisture content at different periods of seed storage in soybean

	Initial after seed treatment				2 months				4 months				6 months			
	V_1	**V_2**	**V_3**	**Mean**	**V_1**	**V_2**	**V_3**	**Mean**	**V_1**	**V_2**	**V_3**	**Mean**	**V_1**	**V_2**	**V_3**	**Mean**
T_1	10.00 (18.34)	10.00 (18.34)	10.00 (18.34)	10.00 (18.34)	10.55 (18.83)	10.45 (18.74)	10.41 (18.71)	10.45 (18.73)	10.22 (18.55)	9.87 (18.24)	10.30 (18.45)	10.24 (18.60)	10.69 (10.98)	10.61 (18.90)	10.53 (18.82)	10.61 (18.90)
T_2	10.00 (18.34)	10.00 (18.34)	10.00 (18.34)	10.00 (18.34)	10.51 (18.81)	10.45 (18.75)	10.42 (18.73)	10.43 (18.73)	10.25 (18.28)	9.95 (18.32)	10.10 (18.45)	10.20 (18.52)	10.67 (18.97)	10.55 (18.84)	10.50 (18.81)	10.57 (18.87)
T_3	10.00 (18.34)	10.00 (18.34)	10.00 (18.34)	10.00 (18.34)	10.46 (18.77)	10.37 (18.68)	10.35 (18.66)	10.35 (18.66)	10.21 (18.55)	9.87 (18.24)	10.02 (18.38)	10.18 (18.48)	10.57 (18.87)	10.55 (18.85)	10.47 (18.78)	10.57 (18.81)
T_4	10.00 (18.34)	10.00 (18.34)	10.00 (18.34)	10.00 (18.34)	10.45 (18.75)	10.40 (18.70)	10.34 (18.66)	10.40 (18.70)	10.20 (18.53)	9.95 (18.31)	9.90 (18.26)	10.12 (18.42)	10.57 (18.87)	10.47 (18.78)	10.47 (18.78)	10.50 (18.80)
T_5	10.00 (18.34)	10.00 (18.34)	10.00 (18.34)	10.00 (18.34)	10.42 (18.72)	10.37 (18.65)	10.32 (18.63)	10.36 (18.65)	10.21 (18.56)	9.82 (18.20)	10.00 (18.36)	10.14 (18.45)	10.50 (18.80)	10.55 (18.84)	10.44 (18.75)	10.50 (18.80)
T_6	10.00 (18.34)	10.00 (18.34)	10.00 (18.34)	10.00 (18.34)	10.44 (18.72)	10.35 (18.66)	10.35 (18.66)	10.37 (18.69)	10.15 (18.49)	9.87 (18.25)	10.02 (18.38)	10.09 (18.40)	10.55 (18.84)	10.53 (18.83)	10.47 (18.78)	10.52 (18.83)
T_7	10.00 (18.34)	10.00 (18.34)	10.00 (18.34)	10.00 (18.34)	10.69 (18.96)	10.42 (18.73)	10.47 (18.77)	10.53 (18.83)	10.37 (18.69)	9.93 (18.30)	10.05 (18.40)	10.24 (18.60)	10.77 (19.05)	10.65 (18.93)	10.62 (18.91)	10.68 (18.95)
Mean	10.00 (18.34)	10.00 (18.34)	10.00 (18.34)	10.00 (18.34)	10.50 (18.80)	10.42 (18.72)	10.38 (18.65)		10.23 (18.58)	10.21 (18.55)	10.05 (18.40)		10.62 (18.92)	10.54 (18.82)	10.50 (18.80)	

	Initial after seed treatment			**2 months**				**4 months**				**6 months**			
				V	**T**	**V x T**		**V**	**T**	**V x T**		**V**	**T**	**V x T**	
S Em±				0.01	0.02	0.02		0.01	0.02	0.03		0.01	0.01	0.02	
CD at 5 %				NS	NS	NS		NS	NS	NS		NS	NS	NS	

Figures in parentheses are angular transformed values

Note:

V_1: LSB-3
V_2: JS-335
V_3: MACS-450

T_1: *Bacillus subtilis*
T_2: *Pseudomonas fluorescens* .
T_3: *Trichoderma harzianum*
T_4: *Trichoderma viride*

T_5: thiram
T_6: thiram+carbendazim
T_7: control

Table 2a : Effect of seed treatments and containers on seedling vigour index at different periods of seed storage in soybean

	Initial after seed treatment				2 months				4 months				6 months			
	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
T_1	6204	6707	6263	6391	5851	6500	6105	6152	5816	6667	6333	6272	5066	5951	5727	5581
T_2	6285	6792	6323	6467	6452	6593	6233	6426	5884	6805	6431	6373	5157	6035	5802	5665
T_3	6470	6925	6514	6636	6378	6884	6386	6549	6042	7137	6608	6596	5397	6292	6075	5921
T_4	6576	7105	6628	6770	6489	7000	6463	6651	6177	7231	6759	6722	5621	6384	6164	6056
T_5	6638	7247	6822	6902	6679	7099	6722	6833	6449	7406	6967	6941	5947	6734	6452	6378
T_6	6452	7121	6740	6771	6506	7068	6625	6733	5968	7199	6829	6665	5773	6576	6283	6211
T_7	6002	6538	5985	6175	5952	6446	5873	6090	5709	6829	6105	6214	5079	5834	5505	5473
Mean	6375.29	6919.29	6467.86		6329.57	6798.57	6343.86		6006.43	7039.14	6576		5434.29	6258	6001.14	

	Initial after seed treatment			2 months				4 months				6 months			
				V	T	V x T		V	T	V x T		V	T	V x T	
SEm$\pm$				3.21	4.90	8.49		30.73	46.95	81.32		2.60	3.97	6.89	
CD at 5 %				8.90	13.50	23.54		85.10	130.0	NS		7.22	11.02	19.10	

V_1: LSB-3
V_2: JS-335
V_3: MACS-450

T_1: *Bacillus subtilis*
T_2: *Pseudomonas fluorescens* .
T_3: *Trichoderma harzianum*
T_4: *Trichoderma viride*

T_5: thiram
T_6: thiram+carbendazim
T_7: control

Table 5a : Effect of seed treatments and containers on electrical conductivity of seed leachates at different periods of seed storage in soybean

	Initial after seed treatment				2 months				4 months				6 months			
	V_1	**V_2**	**V_3**	**Mean**	**V_1**	**V_2**	**V_3**	**Mean**	**V_1**	**V_2**	**V_3**	**Mean**	**V_1**	**V_2**	**V_3**	**Mean**
T_1	1350	910	980	1080	1423	1127	1297	1282	2016	1299	1432	1582	3604	2277	2646	2842
T_2	1350	910	980	1080	1427	1089	1272	1263	1996	1301	1404	1567	3579	2249	2615	2814
T_3	1350	910	980	1080	1398	985	1192	1192	1852	1180	1321	1451	3541	2135	2434	2703
T_4	1350	910	980	1080	1391	981	1186	1186	1837	1205	1317	1453	3470	2098	2648	2739
T_5	1350	910	980	1080	1367	965	1016	1116	1527	1010	1121	1219	2398	1741	1944	2028
T_6	1350	910	980	1080	1373	992	1047	1137	1592	1026	1132	1250	2505	1788	2108	2134
T_7	1350	910	980	1080	1455	1226	1290	1324	2079	1349	1468	1632	3640	2276	2655	2857
Mean	1350	910	980	1080	1405	1052	1186		1843	1196	1314		3248	2081	2436	

	Initial after seed treatment			**2 months**				**4 months**				**6 months**			
				V	**T**	**V x T**		**V**	**T**	**V x T**		**V**	**T**	**V x T**	
SEm±				3.25	4.96	8.60		2.71	4.15	7.19		16.71	25.53	44.23	
CD at 5 %				9.00	13.75	28.83		7.53	11.50	11.50		46.34	70.78	122.60	

V_1: LSB-3
V_2: JS-335
V_3: MACS-450

T_1: *Bacillus subtilis*
T_2: *Pseudomonas fluorescens* .
T_3: *Trichoderma harzianum*
T_4: *Trichoderma viride*

T_5: thiram
T_6: thiram+carbendazim
T_7: control

Contd.. 1b : (V x C)

	0 month	2 months			4 months			6 months		
	Initial	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
V_1	88.92 (70.56)	86.92 (68.90)	89.29 (71.02)	88.11 (69.96)	82.95 (65.66)	86.15 (68.26)	84.55 (66.96)	72.25 (58.25)	82.32 (65.19)	77.28 (61.72)
V_2	89.43 (71.16)	86.72 (68.82)	89.53 (71.22)	88.12 (70.02)	89.89 (71.72)	90.72 (72.47)	90.30 (72.10)	80.43 (63.87)	88.42 (70.24)	84.43 (67.06)
V_3	87.23 (69.20)	85.51 (67.74)	86.33 (68.42)	85.92 (68.08)	88.08 (69.97)	88.72 (70.55)	88.40 (70.26)	77.94 (62.08)	86.67 (68.77)	82.31 (65.42)
Mean	88.53 (70.32)	86.38 (68.49)	88.38 (70.22)		86.97 (69.12)	88.53 (70.43)		76.87 (61.40)	85.80 (68.07)	

	2 months			4 months			6 months		
	C	**V**	**C x V**	**C**	**V**	**C x V**	**C**	**V**	**C x V**
SEm$\pm$	0.11	0.17	0.15	0.09	0.13	0.12	0.11	0.17	0.12
CD at 5 %	0.30	0.46	0.43	0.24	0.37	0.34	0.32	0.48	NS

Figures in parentheses are angular transformed values

C_1: cloth bag
C_2: polylined cloth bag

V_1: LSB-3
V_2: JS-335
V_3: MACS-450

Contd.. 2b : (V x C)

	0 month	2 months			4 months			6 months		
	Initial	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
V_1	6375	6317	6342	6329	5826	6187	6006	5038	5830	5434
V_2	6919	6737	6860	6799	6944	7135	7039	5791	6724	6258
V_3	6468	6313	6374	6344	6539	6613	6576	5601	6401	6001
Mean	6587	6456	6526		6436	6645		5477	6319	

	2 months			4 months			6 months		
	C	**V**	**C x V**	**C**	**V**	**C x V**	**C**	**V**	**C x V**
SEm$\pm$	2.65	3.21	4.54	25.0	30.73	43.46	2.12	2.60	3.68
CD at 5 %	7.26	8.90	12.58	69.5	85.1	120.40	5.89	7.22	10.21

C_1: cloth bag
C_2: polylined cloth bag

V_1: LSB-3
V_2: JS-335
V_3: MACS-450

Contd.. 3b : (V x C)

	0 month	2 months			4 months			6 months		
	Initial	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
V_1	12.00 (20.27)	12.71 (21.02)	8.14 (16.58)	10.40 (18.80)	12.00 (20.49)	8.21 (16.65)	10.13 (18.57)	12.91 (21.06)	8.32 (16.77)	10.65 (18.91)
V_2	12.05 (20.31)	12.70 (20.88)	8.10 (16.53)	10.42 (18.70)	11.96 (19.96)	8.13 (16.57)	9.95 (18.26)	12.87 (21.02)	8.24 (16.69)	10.68 (18.85)
V_3	12.03 (20.29)	12.69 (20.83)	8.11 (16.55)	10.40 (18.69)	11.95 (20.18)	8.14 (16.58)	10.05 (18.38)	12.89 (20.90)	8.27 (16.79)	10.70 (18.81)
Mean	12.02 (20.29)	12.74 (20.91)	8.12 (16.55)		11.98 (20.21)	8.10 (16.60)		12.95 (20.99)	8.28 (16.72)	

	2 months			4 months			6 months		
	C	**V**	**C x V**	**C**	**V**	**C x V**	**C**	**V**	**C x V**
SEm±	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.01
CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS

Figures in parentheses are angular transformed values

C_1: cloth bag
C_2: polylined cloth bag

V_1: LSB-3
V_2: JS-335
V_3: MACS-450

Contd.. 4b : (V x C)

	0 month	2 months			4 months			6 months		
	Initial	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
V_1	10.48 (15.86)	16.28 (22.89)	14.42 (21.31)	15.35 (22.10)	18.07 (24.33)	14.53 (21.92)	16.30 (23.12)	26.33 (30.48)	18.82 (25.41)	22.58 (27.94)
V_2	7.84 (13.70)	13.39 (21.21)	9.78 (17.68)	11.58 (19.44)	14.24 (21.92)	11.64 (19.64)	12.94 (20.78)	19.85 (26.17)	14.44 (22.10)	17.15 (24.14)
V_3	8.64 (14.42)	13.71 (21.05)	10.25 (17.91)	11.98 (19.48)	15.61 (22.89)	11.65 (19.58)	13.62 (21.23)	21.55 (27.35)	14.69 (22.35)	18.12 (24.85)
Mean	8.99 (14.66)	14.46 (21.72)	11.48 (18.97)		15.97 (23.05)	12.61 (20.38)		22.58 (28.00)	15.98 (23.29)	

	2 months			**4 months**			**6 months**		
	C	**V**	**C x V**	**C**	**V**	**C x V**	**C**	**V**	**C x V**
SEm±	0.12	0.14	0.21	0.07	0.08	0.12	0.02	0.02	0.03
CD at 5 %	0.33	0.41	0.57	0.19	0.23	0.33	0.05	0.06	0.09

Figures in parentheses are angular transformed values

C_1: cloth bag — V_1: LSB-3

C_2: polylined cloth bag — V_2: JS-335

V_3: MACS-450

Contd.. 5b : (V x C)

	0 month	2 months			4 months			6 months		
	Initial	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**	**C_1**	**C_2**	**Mean**
V_1	1350	1444	1366	1405	2029	1656	1843	4029	2467	3248
V_2	910	1039	1065	1052	1235	1156	1196	2385	1776	2081
V_3	980	1382	990	1186	1450	1177	1313	3009	1862	2436
Mean	1080	1288	1140		1571	1330		3141	2035	

	2 months			4 months			6 months		
	C	**V**	**C x V**	**C**	**V**	**C x V**	**C**	**V**	**C x V**
SEm$\pm$	2.65	3.25	4.59	2.21	2.71	3.84	13.65	16.71	23.64
CD at 5 %	7.35	4.59	12.74	6.15	7.53	10.65	37.83	46.34	65.53

C_1: cloth bag
C_2: polylined cloth bag

V_1: LSB-3
V_2: JS-335
V_3: MACS-450

Contd.. 1C (T x C)

	Initial after seed treatment	2 months			4 months			6 months		
		C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean
T_1	86.89 (68.80)	83.83 (66.29)	85.74 (67.84)	84.78 (67.07)	84.30 (66.71)	84.99 (67.26)	84.64 (66.98)	73.62 (59.14)	82.84 (65.56)	78.23 (62.35)
T_2	87.35 (69.19)	84.66 (66.95)	86.95 (68.85)	85.81 (67.90)	85.01 (67.31)	87.06 (68.94)	86.04 (68.13)	74.50 (59.71)	83.93 (66.44)	79.21 (63.07)
T_3	88.97 (70.63)	87.69 (69.49)	88.34 (70.06)	88.01 (69.78)	87.66 (69.62)	88.39 (70.17)	88.03 (69.89)	76.23 (60.90)	86.19 (68.31)	81.21 (64.60)
T_4	89.93 (71.52)	87.64 (69.51)	89.01 (70.68)	88.32 (70.10)	88.65 (70.52)	89.87 (71.62)	89.26 (71.06)	77.41 (61.68)	87.31 (69.34)	82.36 (65.51)
T_5	91.33 (72.91)	90.44 (72.01)	92.16 (73.80)	91.30 (72.91)	91.12 (72.95)	92.68 (74.45)	91.90 (73.70)	82.62 (65.51)	89.75 (71.47)	86.19 (68.49)
T_6	90.81 (72.40)	89.10 (70.74)	91.25 (72.84)	90.17 (71.79)	89.75 (71.55)	91.70 (73.31)	90.73 (72.43)	81.50 (64.63)	88.64 (70.40)	85.07 (67.51)
T_7	84.43	81.33	85.24	83.28	82.32	85.01	83.67	70.25	80.50	

	(66.80)	(64.41)	(67.48)	(65.95)	(65.16)	(67.27)	(66.21)	(58.25)	(64.85)	75.37 (61.60)
		2 months			4 months			6 months		
		C	**T**	**C x T**	**C**	**T**	**C x T**	**C**	**T**	**C x T**
SEm±		0.11	0.15	0.23	0.09	0.12	0.19	0.11	0.17	0.25
CD at 5 %		0.30	0.43	0.65	0.24	0.17	0.27	0.32	0.26	0.35

Figures in parentheses are angular transformed values

C_1: cloth bag
C_2: polylined cloth bag

T_1: *Bacillus subtilis*
T_2: *Pseudomonas fluorescens* .
T_3: *Trichoderma harzianum*
T_4: *Trichoderma viride*

T_5: thiram
T_6: thiram+carbendazim
T_7: control

Contd.. 2C (T x C)

	Initial after seed treatment	2 months			4 months			6 months		
		C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean
T_1	6391	6122	6182	6152	6200	6344	6272	5106	6056	5581
T_2	6466	6427	6424	6426	6276	6471	6373	5169	6160	5665

T_3	6636	6527	6572	6549	6569	6622	6595	5495	6347	5921
T_4	6769	6627	6675	6651	6671	6773	6722	5628	6484	6056
T_5	6902	6773	6893	6833	6890	6991	6940	6066	6689	6377
T_6	6771	6681	6785	6733	6465	6866	6665	5832	6589	6210
T_7	6175	6033	6148	6090	5982	6446	6214	5039	5906	5473

	2 months			**4 months**			**6 months**		
	C	**T**	**C x T**	**C**	**T**	**C x T**	**C**	**T**	**C x T**
SEm±	2.65	4.90	6.93	25.00	46.95	66.39	2.12	3.97	5.62
CD at 5 %	7.26	13.50	19.22	69.50	130.10	184.00	5.89	11.02	15.59

C_1: cloth bag
C_2: polylined cloth bag

T_1: *Bacillus subtilis*
T_2: *Pseudomonas fluorescens* .
T_3: *Trichoderma harzianum*
T_4: *Trichoderma viride*

T_5: thiram
T_6: thiram+carbendazim
T_7: control

Contd.. 3C (T x C)

	Initial after seed treatment		2 months			4 months			6 months		
	C_1	C_2	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean
T_1	12.00 (20.26)	8.00 (16.50)	12.78 (20.90)	8.10 (16.54)	10.44 (18.77)	11.98 (20.25)	8.14 (16.58)	10.06 (18.41)	12.93 (21.07)	8.25 (16.73)	10.27 (18.60)
T_2	12.00 (20.26)	8.00 (16.50)	12.80 (12.90)	8.14 (16.58)	10.47 (18.74)	12.02 (20.28)	8.17 (16.61)	10.09 (18.44)	12.83 (20.99)	8.31 (16.70)	10.28 (18.60)
T_3	12.00 (20.26)	8.00 (16.50)	12.75 (20.92)	8.11 (16.55)	10.43 (18.73)	11.96 (20.20)	8.15 (16.58)	10.05 (18.39)	12.75 (20.92)	8.31 (16.70)	10.24 (18.55)
T_4	12.00 (20.26)	8.00 (16.50)	12.70 (12.88)	8.12 (16.56)	10.41 (14.72)	11.93 (20.20)	8.10 (16.53)	10.01 (18.36)	12.76 (20.93)	8.20 (16.69)	10.20 (18.54)
T_5	12.00 (20.26)	8.00 (16.50)	12.85 (20.00)	8.13 (16.55)	10.49 (18.27)	12.00 (20.28)	8.19 (16.63)	10.09 (18.45)	12.76 (20.93)	8.24 (16.67)	10.25 (18.59)
T_6	12.00 (20.26)	8.00 (16.50)	12.80 (20.99)	8.08 (16.51)	10.44 (18.75)	11.86 (20.14)	8.16 (16.60)	10.01 (18.37)	12.80 (20.97)	8.28 (16.67)	10.22 (18.55)

T_7	12.00 (20.26)	8.00 (16.50)	12.90 (21.05)	8.12 (16.56)	10.51 (18.80)	11.92 (20.28)	8.15 (16.05)	10.03 (18.16)	12.97 (21.08)	8.33 (16.77)	10.28 (18.46)

	2 months			**4 months**			**6 months**		
	C	**T**	**C x T**	**C**	**T**	**C x T**	**C**	**T**	**C x T**
SEm±	0.01	0.02	0.02	0.01	0.02	0.03	0.01	0.01	0.02
CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS

Figures in parentheses are angular transformed values

C_1: cloth bag
C_2: polylined cloth bag

T_1: *Bacillus subtilis*
T_2: *Pseudomonas fluorescens* .
T_3: *Trichoderma harzianum*
T_4: *Trichoderma viride*

T_5: thiram
T_6: thiram+carbendazim
T_7: control

Contd.. 4C (T x C)

	Initial after seed treatment	2 months			4 months			6 months		
		C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean
T_1	12.95 (21.07)	19.16 (25.93)	14.57 (22.39)	16.87 (24.16)	21.33 (27.40)	15.84 (23.43)	18.58 (25.41)	27.87 (31.83)	19.24 (25.98)	23.56 (28.90)
T_2	12.50 (20.68)	18.00 (25.08)	14.25 (22.12)	16.12 (23.60)	19.50 (26.19)	14.83 (22.61)	17.16 (24.40)	26.66 (31.07)	18.03 (25.09)	22.35 (28.08)
T_3	9.66 (18.08)	12.41 (20.60)	11.08 (19.39)	11.75 (19.99)	13.10 (21.20)	12.33 (20.12)	12.71 (20.86)	21.95 (27.92)	15.62 (23.25)	18.79 (25.19)
T_4	8.14 (16.56)	10.83 (19.17)	10.16 (18.48)	10.50 (18.82)	12.00 (20.24)	11.25 (19.54)	11.62 (19.89)	18.91 (25.77)	14.33 (22.21)	16.62 (23.99)
T_5	0.00 (0.00)	6.16 (14.20)	3.50 (10.70)	4.83 (12.45)	8.00 (16.38)	5.83 (13.95)	6.91 (15.16)	12.00 (20.21)	9.33 (17.76)	10.66 (18.99)
T_6	0.00 (0.00)	7.51 (15.76)	4.00 (11.39)	5.75 (13.57)	9.24 (17.67)	6.84 (15.15)	8.04 (16.41)	14.50 (22.34)	10.65 (19.03)	12.57 (20.69)

T_7	19.66 (26.23)	27.17 (31.28)	22.83 (28.30)	25.00 (29.79)	28.66 (32.24)	21.34 (17.46)	25.00 (29.85)	36.16 (36.86)	24.67 (29.65)	30.42 (33.25)
		2 months			**4 months**			**6 months**		
		C	**T**	**C x T**	**C**	**T**	**C x T**	**C**	**T**	**C x T**
SEm$\pm$		2.65	4.90	6.93	25.00	46.95	66.39	2.12	3.97	5.62
CD at 5 %		7.26	13.50	19.22	69.50	130.10	184.00	5.89	11.02	15.59

Figures in parentheses are angular transformed values

C_1: cloth bag
C_2: polylined cloth bag

T_1: *Bacillus subtilis*
T_2: *Pseudomonas fluorescens* .
T_3: *Trichoderma harzianum*
T_4: *Trichoderma viride*

T_5: thiram
T_6: thiram+carbendazim
T_7: control

Contd.. 5C (T x C)

	Initial after seed treatment	2 months			4 months			6 months		
		C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean
T_1	1080	1402	1163	1282	1746	1418	1582	3483	2202	2842
T_2	1080	1366	1160	1263	1719	1415	1567	3454	2175	2814
T_3	1080	1264	1119	1191	1589	1313	1451	3307	2100	2703
T_4	1080	1257	1115	1186	1570	1335	1453	3426	2051	2739
T_5	1080	1125	1106	1116	1266	1172	1219	2334	1720	2027
T_6	1080	1161	1113	1137	1311	1189	1250	2495	1773	2134
T_7	1080	1441	1206	1324	1798	1466	1632	3490	2224	2857

	2 months			4 months			6 months		
	C	**T**	**C x T**	**C**	**T**	**C x T**	**C**	**T**	**C x T**
SEm$\pm$	2.65	4.96	7.02	2.21	4.15	5.87	13.65	25.53	36.11
CD at 5 %	7.35	13.75	19.46	6.15	11.50	16.27	37.83	70.78	100.11

C_1: cloth bag
C_2: polylined cloth bag

T_1: *Bacillus subtilis*
T_2: *Pseudomonas fluorescens* .
T_3: *Trichoderma harzianum*
T_4: *Trichoderma viride*

T_5: thiram
T_6: thiram+carbendazim
T_7: control

Table 6 : Effect of seed treatments on field emergence index of soybean genotypes

Treatments	Varieties			Mean
	V_1	**V_2**	**V_3**	
T_1	46.5	48.0	48.1	47.5
T_2	49.3	50.7	49.6	49.9
T_3	54.9	55.8	54.7	55.1
T_4	56.7	58.3	57.4	57.4
T_5	60.7	62.3	61.7	61.5
T_6	58.6	59.5	61.2	59.8
T_7	43.6	44.9	44.2	44.2
Mean	52.9	54.2	53.8	

	V	**T**	**V x T**	**T x V**
S.Em $\pm$	0.60	0.68	1.12	1.53
CD at 5 %	NS	1.34	NS	NS

V_1: LSB-3
V_2: JS-335
V_3: MACS-450

T_1: *Bacillus subtilis*
T_2: *Pseudomonas fluorescens* .
T_3: *Trichoderma harzianum*
T_4: *Trichoderma viride*

T_5: thiram
T_6: thiram+carbendazim
T_7: control

Table 7 : Effect of seed treatments on seedling mortality of soybean genotypes

Treatments	Varieties			Mean
	V_1	V_2	V_3	
T_1	16.5 (23.96)	14.8 (22.62)	15.3 (23.05)	15.5 (23.21)
T_2	15.8 (23.42)	13.7 (21.72)	14.4 (22.3)	14.6 (22.48)
T_3	13.4 (21.47)	11.5 (19.81)	12.3 (20.53)	12.4 (20.6)
T_4	12.4 (20.62)	10.2 (18.61)	11.9 (20.17)	11.5 (19.8)
T_5	9.6 (18.05)	7.5 (15.89)	8.6 (17.05)	8.6 (16.99)
T_6	10.3 (18.71)	8.4 (16.84)	9.7 (18.14)	9.5 (17.9)
T_7	23.6 (29.05)	21.7 (27.63)	22.5 (28.29)	22.6 (28.32)
Mean	14.5 (22.18)	12.5 (20.45)	13.5 (21.36)	

	V	T	V x T	T x V
S.Em $\pm$	0.49	0.50	0.87	1.23
CD at 5 %	NS	1.02	NS	NS

Figures in parentheses are angular transformed values

V_1: LSB-3
V_2: JS-335
V_3: MACS-450

T_1: *Bacillus subtilis*
T_2: *Pseudomonas fluorescens* .
T_3: *Trichoderma harzianum*
T_4: *Trichoderma viride*

T_5: thiram
T_6: thiram+carbendazim
T_7: control

Table 9 : Effect of seed treatments on plant height in soybean genotypes

Treatments	Varieties			Mean
	V_1	V_2	V_3	
T_1	35.12	36.00	33.00	34.70
T_2	34.96	35.75	35.25	35.32
T_3	35.13	36.00	34.50	35.21
T_4	35.00	35.00	35.00	35.00
T_5	35.65	36.50	35.25	35.80
T_6	35.10	34.75	36.00	35.28
T_7	35.15	35.75	34.75	35.71
Mean	35.15	35.67	35.03	

	V	T	V x T	T x V
S.Em $\pm$	0.18	0.31	0.53	0.49
CD at 5 %	NS	NS	NS	NS

V_1: LSB-3
V_2: JS-335
V_3: MACS-450

T_1: *Bacillus subtilis*
T_2: *Pseudomonas fluorescens* .
T_3: *Trichoderma harzianum*
T_4: *Trichoderma viride*

T_5: thiram
T_6: thiram+carbendazim
T_7: control

Table 8b : Effect of seed treatment on the incidence of seed borne diseases of soybean genotypes

	LSB-3		JS-335		MACS-450	
	Disease Incidence (%)	**Scale (0-9)**	**Disease Incidence (%)**	**Scale (0-9)**	**Disease Incidence (%)**	**Scale (0-9)**
Root rot	3.0	5	2.5	5	2.0	5
Pea nut bud necrosis virus	0.8	4	1.0	4	1.0	4
Anthraconose	2.0	2	1.5	2	2.5	2
Purple seed stain	2.0	4	2.0	4	2.0	4
Alternaria leaf spot	1.5	4	1	4	1.2	4
Soybean mosaic virus	6.0	5	4.5	5	5.0	5
Yellow mosaic virus	0.5	2	1.0	2	1.0	2
Leaf crinkle virus	0.2	4	0.0	4	0.1	4
Mean	16.0		13.5		14.7	

Table 10 : Effect of seed treatments on total dry matter production of soybean genotypes

Treatments	Varieties			Mean
	V_1	**V_2**	**V_3**	
T_1	14.44	16.87	14.63	15.31
T_2	14.16	16.56	15.16	15.29
T_3	14.73	17.61	15.67	16.00
T_4	14.43	18.42	16.80	16.55
T_5	17.00	20.67	18.94	18.87
T_6	15.60	19.39	17.56	17.51
T_7	13.28	15.13	14.07	14.16
Mean	14.80	17.80	16.11	

	V	**T**	**V x T**	**T x V**
S.Em $\pm$	0.25	0.43	0.61	0.60
CD at 5 %	0.61	0.81	NS	NS

V_1: LSB-3
V_2: JS-335
V_3: MACS-450

T_1: *Bacillus subtilis*
T_2: *Pseudomonas fluorescens* .
T_3: *Trichoderma harzianum*
T_4: *Trichoderma viride*

T_5: thiram
T_6: thiram+carbendazim
T_7: control

Table 11 : Effect of seed treatments on number of plants per plot in soybean genotypes

Treatments	Varieties			Mean
	V_1	**V_2**	**V_3**	
T_1	166.6	171.3	168.3	168.7
T_2	172.6	177.3	174.3	174.7
T_3	185.6	190.0	187.0	187.3
T_4	191.3	196.3	193.3	193.6
T_5	198.3	203.3	200.6	200.7
T_6	198.0	203.0	200.0	200.3
T_7	157.0	162.2	159.6	160.0
Mean	181.3	186.2	183.3	

	V	**T**	**V x T**	**T x V**
S.Em $\pm$	0.07	1.40	2.35	0.90
CD at 5 %	0.19	2.76	NS	NS

V_1: LSB-3
V_2: JS-335
V_3: MACS-450

T_1: *Bacillus subtilis*
T_2: *Pseudomonas fluorescens* .
T_3: *Trichoderma harzianum*
T_4: *Trichoderma viride*

T_5: thiram
T_6: thiram+carbendazim
T_7: control

Table 13 : Effect of seed treatments on seed recovery percentage of soybean genotypes

Treatments	Varieties			Mean
	V_1	**V_2**	**V_3**	
T_1	96.3 (79.0)	97.6 (81.1)	97.0 (80.0)	97.0 (80.0)
T_2	96.6 (79.5)	97.7 (81.3)	97.1 (80.5)	97.1 (80.3)
T_3	97.5 (81.2)	98.0 (81.9)	97.7 (81.0)	97.5 (81.0)
T_4	97.8 (81.8)	98.0 (82.0)	97.9 (81.5)	97.8 (81.5)
T_5	98.5 (83.5)	98.7 (83.5)	98.4 (82.1)	98.4 (82.8)
T_6	98.1 (82.2)	98.4 (82.8)	98.1 (82.1)	98.1 (82.1)
T_7	94.5 (76.5)	96.7 (79.5)	95.8 (82.1)	95.9 (78.5)
Mean	97.1 (80.5)	97.9 (81.7)	95.9 (78.5)	

	V	**T**	**V x T**	**T x V**
S.Em $\pm$	0.10	0.19	0.33	0.27
CD at 5 %	0.27	0.38	0.66	0.57

V_1: LSB-3
V_2: JS-335
V_3: MACS-450

T_1: *Bacillus subtilis*
T_2: *Pseudomonas fluorescens* .
T_3: *Trichoderma harzianum*
T_4: *Trichoderma viride*

T_5: thiram
T_6: thiram+carbendazim
T_7: control

Table 12 : Effect of seed treatments on yield and yield components of soybean genotypes

Treat-ments	Number of seeds per pod				Number of seeds per plant				100 seed weight (g)				Yield per plant (g)				Yield per hectare (kg)			
	Varieties			Mean	Varieties			Mean	Varieties			Mean	Varieties			Mean	Varieties			Mean
	V1	V2	V3		V1	V2	V3		V1	V2	V3		V1	V2	V3		V1	V2	V3	
T_1	2.35	2.41	2.35	2.37	70.2	67.9	67.1	68.4	11.53	12.59	11.97	11.89	8.09	8.27	8.03	8.13	1123	1179	1127	1143
T_2	2.39	2.41	2.41	2.40	66.4	73.1	72.6	71.1	11.51	12.18	11.72	11.81	7.70	8.91	8.51	8.40	1117	1316	1236	1223
T_3	2.40	2.41	2.39	2.40	67.4	80.4	72.9	74.2	11.79	12.26	11.89	11.98	8.18	9.86	8.67	8.90	1256	1561	1350	1390
T_4	2.42	2.44	2.40	2.42	67.5	84.5	81.8	78.0	11.64	12.32	11.97	11.98	7.88	10.42	9.80	9.37	1260	1705	1579	1513
T_5	2.48	2.52	2.47	2.49	77.6	92.4	91.7	87.2	11.93	12.63	12.13	12.23	9.25	11.86	11.13	10.69	1530	1978	1861	1789
T_6	2.43	2.42	2.43	2.43	72.9	88.9	82.7	81.5	11.81	12.45	12.08	12.11	8.61	11.07	10.00	9.90	1422	1873	1665	1653
T_7	2.37	2.40	2.37	2.38	61.2	67.7	63.2	64.0	11.38	12.00	11.31	11.57	6.96	7.65	7.60	7.41	914	1037	1010	987
Mean	2.41	2.43	2.40		69.5	78.7	76.6		11.65	12.29	11.87		8.11	9.69	9.11		1232	1521	1404	

	Number of seeds per pod				Number of seeds per plant				100 seed weight (g)				Yield per plant (g)				Yield per hectare (kg)			
	V	T	V x T	T x V	V	T	V x T	T x V	V	T	V x T	T x V	V	T	V x T	T x V	V	T	V x T	T x V
S.Em $\pm$	0.01	0.02	0.03	0.02	1.08	1.62	2.80	2.85	0.08	0.13	0.22	0.22	0.09	0.18	0.30	0.25	14.94	29.50	51.10	41.40
CD at 5 %	0.02	0.03	NS	NS	3.00	3.28	5.69	6.11	0.23	0.26	NS	NS	0.25	0.36	0.62	0.52	41.49	59.90	103.70	86.70

V_1: LSB-3
V_2: JS-335
V_3: MACS-450

T_1: *Bacillus subtilis*
T_2: *Pseudomonas fluorescens* .
T_3: *Trichoderma harzianum*
T_4: *Trichoderma viride*

T_5: thiram
T_6: thiram+carbendazim
T_7: control

Table 14 : Effect of seed treatment on seed quality parameters of the harvested produce of soybean genotypes

Treatments	Germination percent				Seedling vigour				Total fungal colonies (%)			
	Varieties			Mean	Varieties			Mean	Varieties			Mean
	V1	V2	V3		V1	V2	V3		V1	V2	V3	
T_1	88.0 (69.8)	91.2 (72.8)	90.0 (71.6)	89.7 (71.4)	6300	6535	6597	6477	11.90 (20.18)	9.20 (17.66)	11.10 (19.46)	10.73 (19.10)
T_2	89.0 (70.9)	92.6 (74.4)	91.3 (72.9)	91.0 (72.7)	6408	6748	6743	6633	11.20 (19.55)	8.78 (17.24)	10.78 (19.17)	10.26 (18.65)
T_3	91.0 (72.6)	93.0 (74.8)	92.5 (74.1)	92.1 (73.9)	6571	6859	6854	6761	9.30 (17.75)	7.2 (15.56)	9.0 (17.46)	8.5 (16.93)
T_4	92.0 (73.7)	94.0 (76.0)	93.0 (74.7)	93.0 (74.8)	6725	6924	6919	6856	9.10 (17.56)	7.0 (15.34)	8.7 (17.15)	8.27 (16.68)
T_5	93.6 (76.0)	96.0 (78.0)	95.0 (77.1)	94.8 (77.2)	6874	7139	7134	7049	5.0 (12.92)	3.73 (11.14)	4.22 (7.85)	4.32 (11.97)
T_6	92.6 (74.7)	94.5 (76.5)	93.5 (75.2)	93.5 (75.5)	6751	6980	6975	6902	6.50 (14.77)	4.5 (12.25)	5.73 (13.85)	5.58 (13.62)
T_7	87.0 (69.0)	90.0 (71.5)	89.0 (70.6)	88.6 (70.4)	6116	6660	6505	6407	13.5 (21.56)	11.25 (19.60)	12.23 (20.47)	12.33 (20.54)
Mean	90.4 (72.4)	93.0 (74.9)	92.0 (73.7)		6667	6826	6818		9.50 (17.75)	7.38 (15.54)	8.82 (17.06)	
	Germination percent				Seedling vigour				Total fungal colonies			
	V	T	V x T	T x V	V	T	V x T	T x V	V	T	V x T	T x V
S.Em ±	0.92	1.29	0.14	0.23	28.08	39.85	73.58	69.02	0.05	0.13	2.24	2.42
CD at 5 %	NS	2.62	NS	NS	77.97	80.82	NS	NS	0.13	0.26	NS	NS

Figures in parentheses are angular transformed values

V_1: LSB-3
V_2: JS-335
V_3: MACS-450

T_1: *Bacillus subtilis*
T_2: *Pseudomonas fluorescens* .
T_3: *Trichoderma harzianum*

T_5: thiram
T_6: thiram+carbendazim
T_7: control *Trichoderma viride*

Table 8a: Effect of seed treatments on disease incidence at different stages of crop growth in soybean genotypes

Treatments	25 days				50 days				75 days			
	Varieties			Mean	Varieties			Mean	Varieties			Mean
	V_1	V_2	V_3		V_1	V_2	V_3		V_1	V_2	V_3	
T_1	10.5 (18.9)	7.4 (15.7)	8.4 (16.9)	8.7 (17.1)	17.0 (24.3)	13.6 (21.6)	14.8 (22.6)	15.1 (22.8)	20.0 (26.5)	16.5 (23.9)	17.7 (24.9)	18.0 (25.1)
T_2	9.2 (17.6)	6.05 (14.2)	7.1 (15.4)	7.4 (15.7)	15.0 (22.7)	11.8 (20.0)	13.0 (21.1)	13.2 (21.3)	18.5 (25.4)	15.2 (22.9)	16.4 (23.8)	16.7 (24.1)
T_3	8.6 (17.0)	5.4 (13.4)	6.6 (14.9)	6.8 (15.1)	11.6 (19.9)	8.2 (16.6)	9.5 (17.9)	9.7 (18.1)	15.2 (22.9)	11.9 (20.1)	12.9 (21.1)	13.3 (21.4)
T_4	8.2 (16.6)	5.0 (12.9)	6.1 (14.3)	6.4 (14.6)	11.2 (19.5)	8.0 (16.4)	9.1 (17.5)	9.4 (17.8)	14.6 (22.4)	11.1 (19.4)	12.9 (20.5)	12.6 (20.8)
T_5	6.7 (15.0)	3.5 (10.7)	4.6 (12.3)	4.9 (12.7)	9.2 (17.6)	5.8 (14.0)	7.0 (15.3)	7.3 (15.6)	12.0 (20.2)	8.8 (17.2)	9.9 (18.3)	10.2 (18.6)
T_6	7.2 (15.5)	4.0 (11.5)	5.0 (13.0)	5.4 (13.6)	9.6 (18.0)	6.2 (14.4)	7.4 (15.7)	7.7 (16.0)	12.6 (20.8)	9.3 (17.7)	10.5 (18.9)	10.8 (19.1)
T_7	12.8 (20.9)	9.2 (17.6)	10.6 (19.0)	10.8 (19.2)	20.5 (26.9)	17.0 (24.3)	18.3 (25.3)	18.6 (25.5)	23.1 (28.7)	19.3 (26.0)	21.7 (27.7)	21.3 (27.5)
Mean	9.03 (17.3)	5.7 (13.7)	6.9 (15.1)		13.4 (21.3)	10.0 (18.2)	11.3 (19.3)		16.0 (23.4)	13.5 (21.3)	14.7 (22.3)	

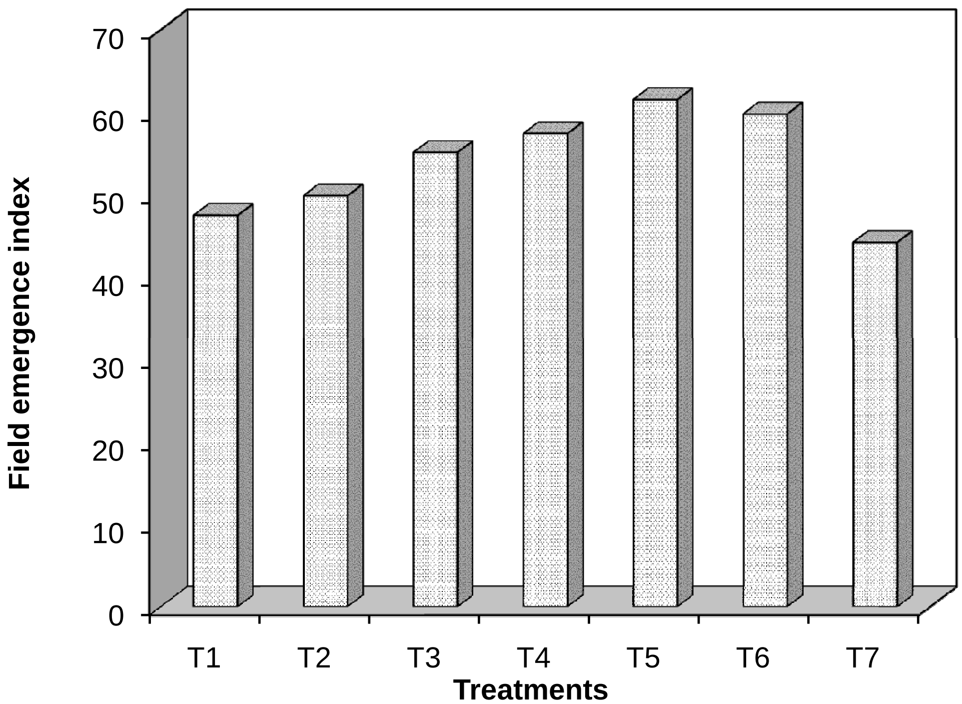
	25 days				50 days				75 days			
	V	**T**	**V X T**		**V**	**T**	**V X T**		**V**	**T**	**V X T**	
SEm ±	0.12	0.16	0.28		0.27	0.41	0.70		0.51	0.29	0.50	
CD at 5%	0.33	0.33	NS		0.75	0.82	NS		1.41	0.59	1.01	

Figures in parentheses are angular transformed values

V_1: LSB-3
V_2: JS-335
V_3: MACS-450

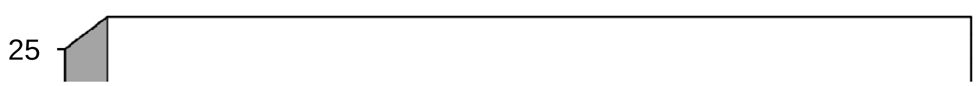
T_1: *Bacillus subtilis*
T_2: *Pseudomonas fluorescens*
T_3: *Trichoderma harzianum*

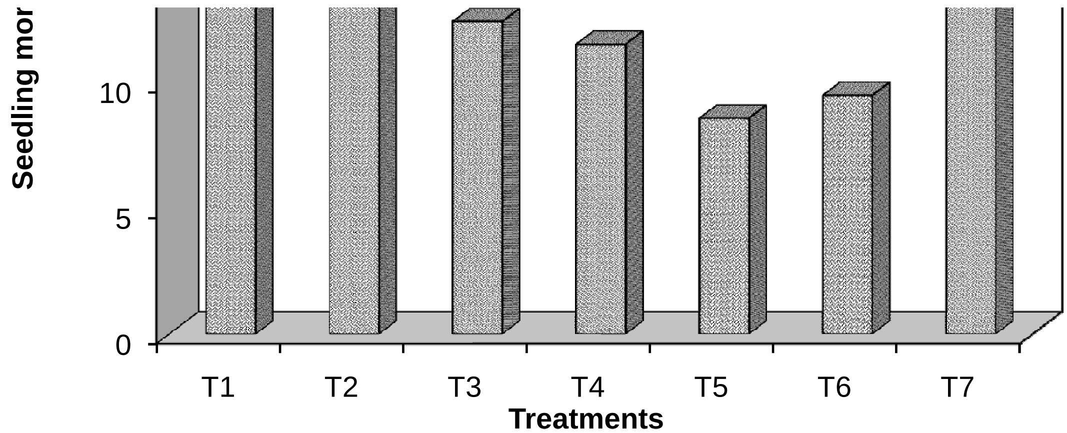
T_5: thiram
T_6: thiram+carbendazim
T_7: control *hoderma viride*



T1 – *Bacillus subtilis*
T2 – *Pseudomonas fluorescens*
T3 – *Trichoderma harzianum*
T4 – *Trichoderma viride*
T5 – Thiram
T6 – Thiram + Carbendazim
T7 – Control

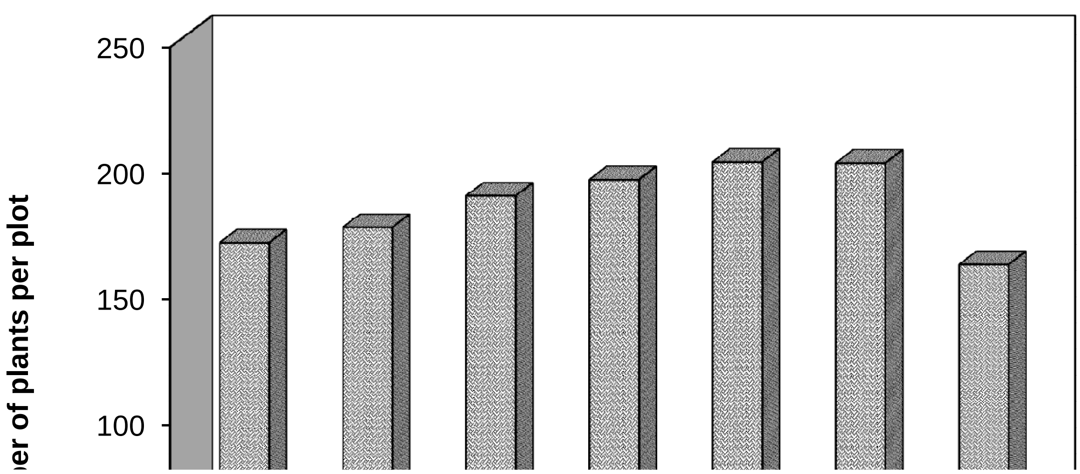
Fig. 1 : Effect of seed treatments on field emergence index





T1 – *Bacillus subtilis*
T2 – *Pseudomonas fluorescens*
T3 – *Trichoderma harzianum*
T4 – *Trichoderma viride*
T5 – Thiram
T6 – Thiram + Carbendazim
T7 – Control

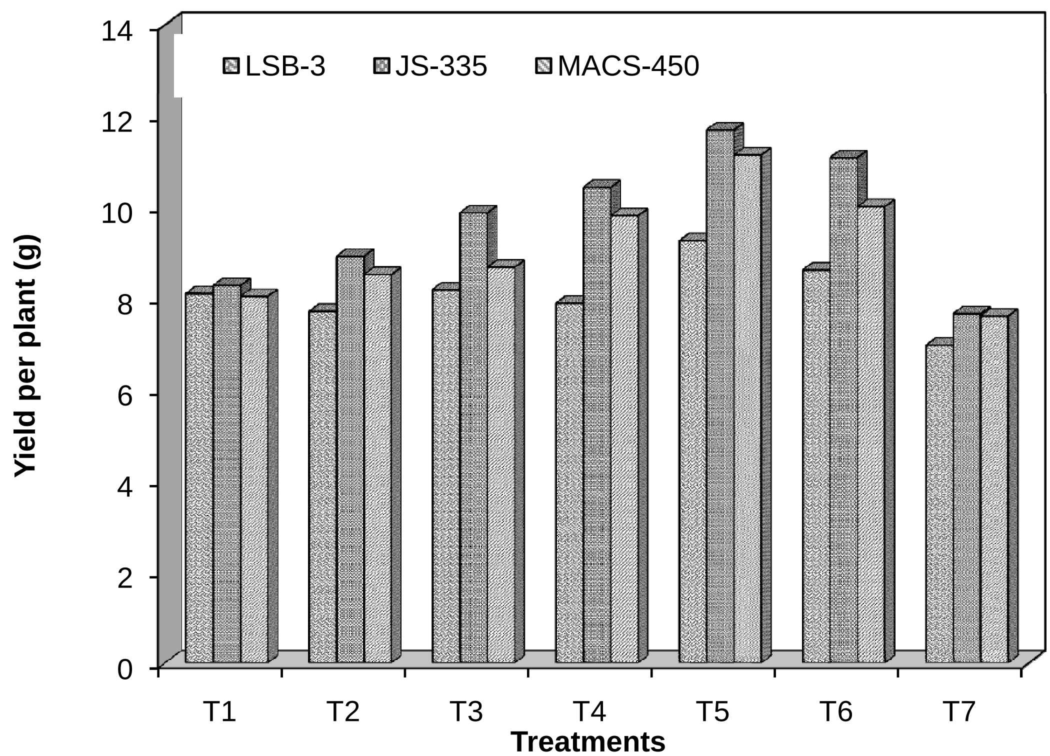
Fig. 2 : Effect of seed treatments on seedling mortality



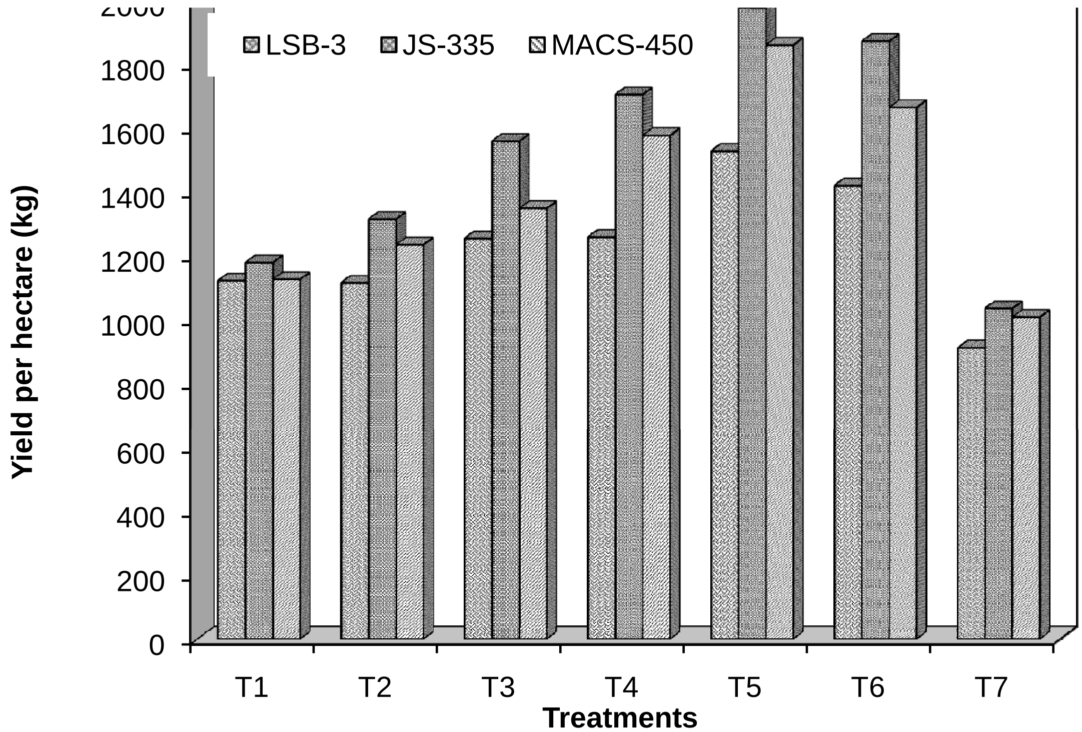
Treatments

T1 – *Bacillus subtilis*
T2 – *Pseudomonas fluorescens*
T3 – *Trichoderma harzianum*
T4 – *Trichoderma viride*
T5 – Thiram
T6 – Thiram + Carbendazim
T7 – Control

Fig. 4 : Effect of seed treatments on number of plants per plot

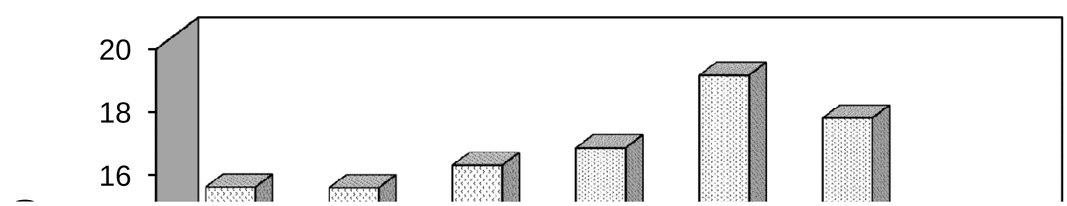


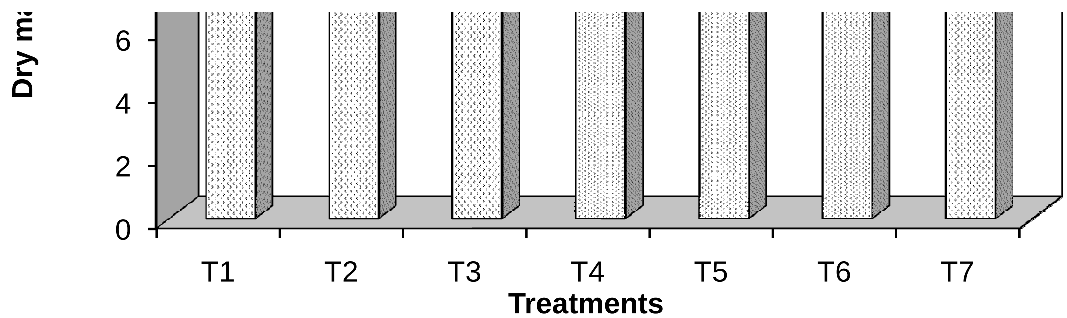
T1 – *Bacillus subtilis*
T2 – *Pseudomonas fluorescens*
T3 – *Trichoderma harzianum*
T4 – *Trichoderma viride*
T5 – Thiram
T6 – Thiram + Carbendazim
T7 – Control



T1 – *Bacillus subtilis*
T2 – *Pseudomonas fluorescens*
T3 – *Trichoderma harzianum*
T4 – *Trichoderma viride*
T5 – Thiram
T6 – Thiram + Carbendazim
T7 – Control

Fig. 6 : Effect of seed treatments on yield per hectare (kg) of three soybean genotypes





T1 – *Bacillus subtilis*
T2 – *Pseudomonas fluorescens*
T3 – *Trichoderma harzianum*
T4 – *Trichoderma viride*
T5 – Thiram
T6 – Thiram + Carbendazim
T7 – Control

Fig. 3 : Effect of seed treatments on dry matter production (g)

increasing germination. The interaction effect between varieties and treatments were not observed in respect of genotypes.

4.3.2 Seedling vigour

Seedling vigour index increased with seed treatments particularly in thiram (7049), thiram+carbendazim (6902) over control. Seedling vigour index was significantly superior in seed treatments as compared to control. Maximum (7049) and minimum (6407) seedling vigour index was recorded with thiram and untreated seed respectively (Table 14).

4.3.3 Seed mycoflora

LSB-3 had maximum number of total fungal colonies (9.5%) and significantly higher than JS-335 (7.38%) and MACS-450 (8.82%). Total fungal colonies were reduced with seed treatments of thiram (4.32%), thiram+carbendazim (5.58 %),

T viride (8.27 %), *T. harzianum* (8.27 %), *P. fluorescens* (10.26 %) and *B. subtilis* (10.73 %) as against control (12.23 %). Least number of fungal colonies were observed in thiram and found superior to other treatments. Among bioagents *T. viride* had less number of fungal colonies than other bioagents. The interaction effect was not observed due to varieties and treatments (Table 14).

CHAPTER V

DISCUSSION

Soybean the “Golden bean” is an important oil seed and pulse crop and the most likely solution for overcoming the world’s protein hunger. One of the major limitation in soybean production is the availability of quality seed at the time of planting. Losses due to seed borne diseases are estimated to the tune of 12 per cent of the total production. Since soybean seed is generally short lived, maintenance of seed viability and vigour from harvest till the next growing season during storage is one of the important criteria. The seed longevity is influenced by the genotype, moisture content, temperature, humidity and seed microflora which are responsible for poor germination and reduced plant stand. The type of storage container and seed treatments with various fungicides play an important role in maintaining viability of soybean seed (Zote and Maye, 1982) and reducing electrical conductivity of seed leachates. Leaching of electrolytes have often been associated with seed vigour, viability and some times with field emergence. Seed treatment with bioagents and fungicides are used to reduce seed borne fungi that cause seedling blight, seed decay and other diseases. Such treatments also protect the germinating seeds from the attack of certain soil inhibiting fungi. The results obtained in this present investigation is briefly discussed under the following headings.

5.1 EFFECT OF SEED TREATMENTS AND CONTAINERS ON STORABILITY

5.1.1 Germination percentage, seedling vigour

The germination percentage, seedling vigour and storability were high with seed treatments particularly thiram, thiram + carbendazim followed by *Trichoderma viride* when compared with control in three soybean genotypes. The effectiveness of seed treatments with thiram, thiram + carbendazim in maintaining good viability has been reported by Savitri *et al*. (1998), Solanke *et al*. (1998), Anuja *et al*. (2000) and Meena Kumari *et al*. (2002). The beneficial effect of seed treatment with seed dressing fungicides in minimizing loss in viability is in accordance with Kalavathi *et al*. (2000). The impact of bioagent *T.viride* in improving storability in hybrid rice was reported by Jeevalatha (2004). The present findings also confirm the above finding by using *T.viride* in improving the storability of soybean genotypes. Similar variation in seed storability results has been reported by Banumurthy and Gupta (1981), Vanangamudi (1988), Kuo (1989) and Pushpendra and Kamendra Singh (2002). As the storage period progressed there was a general decline in germination in different treatments in three soybean genotypes which could be attributed to irreversible phenomenon of ageing characteristics of all living organisms causing deteriorative changes in physical, physiological and biological condition of the seed (Abdul Baki and Anderson, 1972).

Gradual reduction in seedling vigour with increase in storage period in case of soybean was reported earlier by Meena Kumari *et al*. (2002).

5.1.2 Seed mycoflora

The per cent total fungal colonies gradually increased with the period of storage in all the genotypes with different seed treatments and containers. A significant variation was observed in total fungal colonies due to genotypes. LSB-3 recorded maximum number of total fungal colonies as compared to JS-335 and MACS-450. Irrespective of genotypes seed treatment with fungicides and biogents exerted a significant influence on total fungal colonies of three soybean genotypes when stored for the period of 6 months. In general there was an increase in the total number of fungal colonies with the advancement of storage period. Among the seed treatments thiram, thiram + carbendazim were most effective followed by *T.viride* which recorded less number of fungal colonies during the entire period of storage when compared with control. Such impact was high with JS-335. Seed treated with fungicides and stored in vapour proof container exhibited less number of fungal colonies than those of cloth bag storage in all the genotypes. Seed treatment with thiram, thiram + carbendazim, *T.viride* and stored in polylined cloth bag were found effective in reducing total number of fungal colonies in three soybean genotypes. The reduction in total number of fungal colonies with seed treatments might be due to the inhibition of seed borne pathogen and thus preventing seed deterioration and loss of membrane integrity. Similar findings were reported by Ravi Kumar *et al*. (1987), Singh *et al*. (1988), Charjan and Tarar (1992), Anuja *et al.* (2001) and Meena Kumari *et al.* (2002).

5.1.3 Electrical conductivity of seed leachates

Irrespective of genotypes untreated seed recorded higher EC of seed leachates than seeds treated with fungicides and bioagents. Seeds packed in vapour proof containers had lesser EC of seed leachates as compared to that of cloth bag storage. It clearly indicates that loss of membrane integrity which is one of the early symptoms of seed ageing was faster in seeds packed in moisture pervious container (cloth bag). Moisture proof container (polylined cloth bag) prevents the seed deterioration by seed borne mycoflora because of non fluctuation of moisture content of seed, maintenance of high membrane integrity, acts as a barrier for air borne mycoflora, reduces lipid peroxidation and prevents release of free radicals. Similar findings were made by Singh and Dadlani (2003).

5.2 FIELD STUDIES

5.2.1 Field emergence index

All seed treatments (bioagents and fungicides) recorded significantly higher field emergence rate than untreated control. This might be due to suppression of the activity of soil borne pathogens which facilitates the emergence and establishment of healthy seedlings. Similar findings were confirmed by Sundaresh and Hiremath (1982), Singh and Agarwal (1988), Kawale *et al*. (1989), Tripathi and Singh (1991), Chung and Ju (1993), Anuja *et al.* (2000) and Raj *et al.* (2002). Among the fungicides thiram, thiram + carbendazim were found effective in improving field emergence. Thiram, thiram + carbendazim controls most of the soil borne pathogen / fungi by seed treatment and improves germination vigour and field emergence. Similar assessment was made by Anuja *et al*. (2000) and Raj *et al*. (2002). Among the bioagents *T.viride* showed higher field emergence with minimum activity of pathogen subsequently enhances seed germination. It could be attributed to the production of not only anti fungal compounds but also growth regulating chytinolytic enzymes like glucanase and protease there by reducing pathogenic activity. Similar assessment was made by Krishnamurthy *et al.* (2003) in pulses.

5.2.2 Seedling mortality and seed borne diseases

Among soybean genotypes LSB-3 recorded maximum occurrence of diseases (16%) followed by JS 335 (13%) and MACS-450 (14.5%). The variation among the genotypes might be due to genotypic factor. Similar variation in disease incidence of different soybean genotypes were confirmed by Singh (1997), Meena Kumari *et al.* (2002) and Vrataric (2002).

Seed treatments particularly thiram, thiram + carbendazim recorded less mortality of seedlings and incidence of seed borne diseases. Fungicide treated seed controlled the external as well as internal seed borne pathogen and there by acts as protective coating to prevent soil borne pathogens from seedling infection. Similar observations were reported by Hall and Xue (1995), Das and Dutta (1999) and Gaulart *et al.* (2000). Seed treatment with fungicides is essential because when the seed germinates a larger number of pathogens carried with seed become active and cause either seed or seedling mortality or produce disease at later stages. The purpose of seed treatments by the use of fungicides is to destroy seed borne fungi that cause seedling blight, seedling decay, root rot and other diseases. Such treatments also protect the germinating seed against certain soil inhibiting fungi.

5.2.3 Total dry matter production (TDMP)

Irrespective of varieties seed treatment with fungicides and bioagents had profound influence in increasing dry weight of the plant in all the genotypes as compared with untreated seed. The increase in dry weight was due to more leaf area, higher plant height, more number of pods per plant, more number of seeds per plant with less incidence of disease. Number of plants in control was less when compared to seed treatments. It might be explained due to seedling mortality and more incidence of diseases at later stages. Similar findings were reported by Negalur *et al.* (2001).

5.2.4 Yield components and yield

Number of pods per plant, number of seeds per plant, seed weight, yield per plant, yield per ha were high in seed treatments with fungicides and bioagents as compared with untreated seed control. Such additional increase was high with thiram, thiram + carbendazim and *T.viride.* The increased yield was attributed to increase in plant stand and plant establishment with suppression of seed borne pathogens. Inhibition of the activity of pathogen resulted in more total dry matter production which facilitates more availability of photosynthates for sink and ultimately resulted in more number of seeds per pod, seed weight and thus increase in yield. Similar findings were observed by Singh and Agarwal (1988), Kawale *et al*. (1989), Thombre *et al*. (1989), Tripathi and Singh (1991), Anuja *et al*. (2000), Taywede *et al*. (2002) and Rajende-pm-de (2003).

- ❖ Present investigation clearly indicates that seed treated with thiram or thiram + carbendazim were very effective for improving the crop productivity by suppression of seedling mortality and seed borne pathogens *Alternaria alternata*, *Macrophomina phaseolina*, *Cercospora kikuchi*, Soybean mosaic virus (SMV), leaf crinkle virus (LCV), yellow mosaic virus (YMV) and peanut bud necrosis virus (PBNV) and these treatments were useful to farmers and seed industry personals for enhancing productivity of the crop.
- ❖ Soybean seeds packed in vapour proof container was very effective for extending the seed longevity and maintaining good seed storability by safe guarding seed deteriorating fungal flora.

CHAPTER VI

SUMMARY

The present investigation was taken up with three soybean genotypes (LSB-3, JS-335 and MACS-450), seed treatments with bioagents (*Trichoderma harzianum, Trichoderma viride, Bacillus substillis* and *Pseudomones fluorescens*), fungicides (thiram, thiram + carbendazim) and two containers (cloth bag, polylined cloth bag) for storability and field performance studies during *rabi* 2003. The results of the present investigation are summarised below.

Under laboratory conditions the germination percentage, seedling vigour and storability were increased with seed treatments particularly thiram, thiram + carbendazim followed by *T.viride* as compared with untreated control. Seeds packed in vapour proof containers had higher germination, seedling vigour and storability at all periods of storage in three soybean genotypes. Seeds treated with fungicides and stored in vapour proof container (Polylined cloth bag) exhibited lesser number of fungal colonies and lesser EC of seed leachates than cloth bag storage in all the genotypes. Seed treatment with thiram, thiram + carbendazim and *T.viride* and stored in polylined cloth bag were effective for reduction of total fungal colonies and leakage of electrolytes in all the soybean genotypes.

Under field evaluation trials field emergence index was high with seed treatments and bioagents against control plot. Seedling mortality and disease

incidence was very low in seeds treated with thiram or thiram + carbendazim. Among bioagents *T.viride*, exhibited superior in reducing seedling mortality and disease incidence in all genotypes.

Total dry matter production, number of seeds per pod, number of seeds per plant, plant stand, 100 seed weight, seed recovery percentage, seed yield per plant, seed yield per ha were increased with seed treatments over control in all the soybean genotypes. Such additional increase was high with thiram, thiram + carbendazim and *T.viride*. The per cent increase in yield with *B. substillis, P. fluorescens, T. harzianum, T.viride*, thiram and thiram + carbendazim were 15.8, 23.8, 40.7, 53.2, 81.2 and 67.4 respectively over untreated control.

The following conclusions have been drawn from the investigation are as follows.

- Seed treatments found effective for improving the field emergence, germination, seedling vigour and storability as a result of low seedling mortality and lesser disease incidence.
- Bio-agents especially T.viride had significant role in maintenance of seed quality, storability, higher yields under field conditions.
- Thiram, thiram + carbendazim improved total dry matter production of the plant, yield and its components.

- It is recommended that either thiram, thiram + carbendazim were effective for obtaining higher yields by suppression of seed borne pathogens at various stages of the crop growth and thus maintaining healthy crop. Bioagent *T.viride* was also similarly effective for the above traits over other bioagents. However *T.viride* is inferior to fungicides seed treatments in respect of seed quality, storability and yield.

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ABSTRACT

Freshly harvested seeds of popular soybean varieties LSB-3, JS-335 and MACS-450 were collected from Agricultural Research Station, Adilabad and treated with bioagents (*Trichoderma viride*, *Trichoderma harzianum, Bacillus substillis* and *Pseudoman fluorescens*) and fungicides (thiram, thiram + carbendazim) and maintaining untreated control. After seed treatment the seeds were sown in field with three replications duly adopting Split Plot Design in order to find out the effect of seed treatments on incidence of seed borne diseases, plant growth parameters, yield and yield components. After seed treatment another portion of seed material of the above soybean genotypes were packed in cloth bag and polylined cloth bag for assessment of seed quality, seedling vigour and storability and data were subjected for Factorial Randomized Block Design (FRBD).

The germination percentage, seedling vigour, field emergence and storability were high in seed treatments particularly thiram, thiram + carbendazim and *T.viride* as a result of suppression of seed borne mycoflora and maintenance of strong membrane integrity. Seeds packed in vapour proof container (polylined cloth bag) were also effective in improving the seed quality, seed germination, seed health, seedling vigour and storability in all the soybean genotypes.

Total dry matter production, number of seeds per pod, number of seeds per plant, plant stand, 100 seed weight, seed recovery percentage, seed yield per plant and seed yield per hectare were increased with seed treatments

particularly thiram, thiram+carbendazim and *T.viride*. An untreated plot recorded 987 kg ha^{-1} and it was inferior to seed treatments. The additional increase of yield per hectare over control were 616, 508, 346 kgs in LSB-3, 941, 836, 668 kgs in JS-335 and 851, 655, 569 kgs in MACS-450 with thiram, thiram + carbendazim and *T.viride* respectively.

Thus it is recommended that seed treatments in soybean either with thiram or thiram + carbendazim and *T.viride* were found effective and beneficial to the farmers for reducing the incidence of seed borne pathogens (*Cercospora kikuchi, Colletotrichum dematium, Alternaria alternate, Macrophomina phaseolina,* Soybean mosaic virus, leaf crinkle virus, yellow mosaic virus and peanut bud necrosis virus) and getting better quality seed and yield in soybean genotypes.

LITERATURE CITED

* Abdul Baki A A and Anderson J D 1973 Vigour determination in soybean seed by multiple criteria. Crop Science 13 : 630-633.

Al Kassim M Y 1996 Seed borne fungi of some vegetables in Saudiarabia and their chemical control. Arab-Gulf. Journal of Scientific Research 14 : 705-715.

Anuja G, Aneja K R and Gupta A 2001 Mycofloral spectrum during storage and its effect on seed viability of soybean seeds under ambient conditions. Proceedings of the National Academy of Sciences. Biological Sciences 71 : 245-253.

Anuja Gupta and Aneja K R 2000 Field efficacy of seed dressing chemicals on seedling emergence, seed yield and seed weight in soybean. Seed Research 28(1) : 54-58.

Anwar S A, Abbas S F, Gill M M, Rouf C A, Mahmood S and Bulla A R 1995 Seed borne fungi of soybean and their effect on seed germination. Pakistan Journal of Phytopathology.

Arulnandhy V and Senanayake Y D A 1988 Deterioration of soybean seed stored in different containers under ambient conditions. Seed Research 16(2) : 183-192.

Arulnandhy V and Senanayake Y D A 1991 Changes in variability, vigour and chemical composition of soybean seeds stored under the humid tropical conditions. Legume Research 14(3) : 135-144.

Banumurthy N and Gupta P C 1981 Germinability and seed vigour of soybean in storage. Seed Research 22(2) : 137-140.

Charjan S K U and Tarar J L 1992 Effect of storage on germination and microflora of soybean (*Glycine max.*) seed. Indian Journal of Agricultural Sciences 62(7) : 500-502.

* Chung K W and Ju J I 1993 Effect of fungicide benoram, seed treatment on germination, growth and yield in summer type soybean. Korean Journal of Crop Science 38 : 166-173.

Centre for Monitoring Indian Economy (CMIE) Annual Report, pp. 240.

* Cook R J and Baker K F 1983 The nature and practice of biological control of Plant Pathogens. American Phytopathological Society St. Paul Minnesota, Academic Press pp. 539.

Das B C and Dutta P 1999 Biological management of stem rot of soybean caused by *Rhizoctonia solanikuhn*. Journal of the Agricultural Science Society of North East India 12(2) : 217-220.

De R K and Chaudhary R G 1999 Biological and chemical seed treatment against lentil wilt. Lens Newsletter 26(1-2) : 28-31.

Gayathri Subbaiah and Indra N 2003 Management of seed and collar rots caused by *Aspergillus niger* Van Tiegham in groundnut (*Arachis hypogaea* L.) by biocontrol method. Madras Agricultural Journal 90 (4-6) : 292-297.

Gaulart A C P, Andrade P J M and Borges E P 2000 Control of soybean seed borne pathogens by fungicide treatment and its effects on emergence and yield. Summa-Phytopathologica 26(3) : 341-356.

Gupta G K and Ansari M M 1988 Studies on survey, surveillance, epidermiology and other biological aspects of major root and seed diseases of soybean. Annual progress report, National Research Centre for soybean. Indore, M.P. pp : 24-25.

Gurmit Singh and Hari Singh 1992 Maintenance of germinability of soybean (*Glycine max*.) seeds. Seed Research 20(1) : 49-50.

* Hall R and Xue A G 1995 Effectiveness of fungicidal seed treatments applied to smooth or shriveled soybean seeds contaminated by Diaporthe Phaseolorum. Phytoprotection 76(2) : 47-56.

Hussain S, Ghaffar A and Aslam M 1990 Biological control of Macrophomena phaseolomia char coal rot of sunflower and mungbean. Journal of Phytopathology 130 : 157-160.

ISTA 1996 International rules for seed testing. Seed Science and Technology 13 : 299-513.

Jayasheela N, Sreeramulu K R, Krishnanaik L and Suvarna C V 1998 Effect of seed dressing fungicides of soybean on *Bradyrhizobium Japonicum* (Kirchner), Jordan. Legumes Research 21(1) : 51-53.

Jeevalatha A 2004 Studies on seed microflora of rice hybrids and their parental lines. M.Sc.(Ag.) Thesis submitted to Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad.

Kalvathi D, Vijaya J, Ananthakalaiselvi and Angamuthu K 2000 Storage potential of farm yard millet seeds. Seed Research 28(1) : 47-49.

Kawale B R, Kurundkar B P and Thombre P A 1989 Effect of fungicides, insecticide, weedicide on emergence and yield of soybean [*Glycine max*. (L.) Merrill]. Journal of Oilseeds Research 6(2) : 357-359.

Krishnamurthy, Niranjana S R and Shetty H S 2003 Effect of chemical fungicides and biological agent on seed quality improvement in pulses. Seed Research 31(1) : 121-124.

Kumar Kant Singh and Malavika Dadlani 2003 Effect of packaging on vigour and viability of soybean (*Glycine max*. (L.) Merill) seed during ambient storage. Seed Research 31(1) : 27-32.

* Kuo W H J 1989 Delayed permeability soybean seeds, characteristics and screening methodology. Seed Science and Technology 17 : 131-142.

Lakshmi B S, Gupta J P and Prasad M S 1998 Influence of fungicidal seed treatment on germination and mycoflora succession of soybean seeds during storage. Annuals of Plant Protection Sciences 6(2) : 136-141.

Manmeet M, Third B S and Manav M 2002 Management of bacterial blight of rice with bioagents. Plant Disease Research 17 : 21-28.

Meena Kumari K V S, Rajeswari B and Reddy B M 2002 Impact of seed borne diseases on seed quality and seed dressing fungicides on storability of soybean. Indian Journal of Plant Protection 30(2) : 139-143.

Munde A V 2003 Effect of screen size on physical properties and seed quality parameters of soybean. Journal of Maharashtra Agricultural University 28(3) : 285-288.

Murthy Y L K and Raveesha K A 1996 Seed mycoflora of soybean in Karnataka. Plant Disease Reporter 4 : 78-82.

Muthu Raj R, Kant K and Kulshrestha D D 2002 Screening soybean cultivars for seed mycoflora and effect of thiram treatment thereon. Seed Research 30(1): 118-121.

Negalur S B, Kurdikeri M B and Shekhargouda M 2001 Effect of seed invigoration on field performance of soybean. Current Research – University of Agricultural Sciences, Bangalore 30 (11-12) : 189-190.

Pannerselvam A and Saravanemuthu R 1996 Antagonistic interaction of some soil fungi against Sarocladium oryzae. Indian Journal of Agricultural Sciences 30(1) : 59-64.

Panse V G and Sukhatme P T 1985 Statistical methods for agricultural workers, edn 4. Indian Council of Agricultural Research, New Delhi pp. 145-2.

Parakhia A M, Akbari L F, Jugnu Antharia, Vaijhnav M V and Antharia J 1998 Comparative evaluation of bio-agents and seed dressing fungicides against Aspergillus niger causing collar rot of groundnut. Gujarat Agricultural University Research Journal 23(2) : 61-64.

Peshney N L, Mahant S F and Ninawe B N 1994 Detection and chemical control of seed borne fungal pathogens of soybean. Journal of Soils and Crops 4(2) : 131-135.

Prasad 2001 Biological control of root and collar rot of chickpea caused by Sclrotium rolfsic. Annals of Plant Protection Sciences 9(2) : 297-303.

Preseley J T 1958 Relations of protoplast permeability in cotton seed viability and predisposition to seedling disease. Plant Dissertation Reporter 42: 752.

Pushpendra and Kamendra Singh 2002 Genotypic variability for seed longevity in soybean, *Glycine max*. L. (Merrill). Journal of Oilseeds Research 19(2) : 175-177.

Raguchander T, Rajappan K and Samiyappan R 1998 Influence of biocontrol agents and organic amendments on soybean root rot. International Journal of Tropical Agriculture 16(1-4) : 247-252.

Rahman M H, Agarwal V K, Thalpliyal P N and Singh R A 1993 Effects of dates of sowing and seed treatment on the yield and quality of soybean. Seed Research 21 : 35-40.

Raj R M, Kant K and Kulshrestha D D 2002 Screening soybean cultivars for seed mycoflora and effect of thiram treatment there on. Seed Research 30(1) : 118-121.

Raja K, Bharathi A and Karivaradaraaju T V 2003 Effect of storage containers and seed treatments on seed viability and vigour of greengram (*Vigna radiata* (L.) wilczek) cv. CO 6. Madras Agricultural Journal 90(7-9) : 550-553.

Rajendra P V, Raghvendra Kumar, Prakash V and Katiyar R P 1990 Germinability of soybean seeds after harvest in subsequent storage. Seed Research 18(1) : 44-46.

Ramanathan A and Siva Prakasam K 1993 Effect of seed treatment with antagonists and fungicides on seed viability and seedling vigour of chilli. In : Crop Diseases Innovative Techniques and Management (eds Siva Prakasam K and Seetha Raman K). Kalyani Publishers, Ludhiana pp. 251-254.

Ravi Kumar C H, Kulkarni G N, Vyakapnal B and Shashidhara S P 1987 Effect of fungicides and insecticides on storability of soybean genotypes. Plant Pathology News Letter 5 (1-2) : 11.

* Rezende P M de, Machado J da C, Gris C F, Gomes L L, Botrel E P, da C Machado J and de Rezende P M 2003 Effect of dry soil sowing and seeds treatment on emergence, yields grains and other characteristics of soybean. Ciencia.e. Agrotecnologia 27(1) : 76-83.

Savitri H, Sugunakar Reddy M and Muralimohan Reddy B 1998 Effect of seed treatment with fungicides and insecticides on seed borne fungi, storage insect pest, seed viability and seedling vigour of groundnut. Seed Research 26(1) : 62-72.

Shamarao Jahagirdar, Yenjerappa S T, Ravikumar M R and Jamadar M M 2002 Field evaluation of biocontrol agents against chickpea wilt. Legumes Research 25(4) : 299-300.

* Sinclair J B 1982 Compendium of soybean diseases IT edition. The American Phytopathological Society. Academia Press, St. Paul Minnesota pp. 104.

Singh D P 1997 Efficacy of fungicidal treatment in different graded seeds in soybean. Legumes Research 20(2) : 124-126.

Singh G and Harisingh 1992 Maintenance of germination of soybean seeds. Seed Research 20(1) : 49-50.

Singh S N and Agarwal S C 1988 Interaction effect of seed dressers and period of exposure on germination and nodulation of soybean. Indian Journal of Plant Pathology 6(1) : 63-66.

Singh S N, Srivastava S K and Agarwal S C 1988 Viability and germination of soybean seeds in relation to pre-treatment with fungicides, period of storage and type of storage container. Tropical Agriculture (Trinidad) 65(2) : 106-108.

Solanke R B, Kore S S and Sudewad S M 1997 Detection of soybean seed borne pathogens and effect of fungicides. Journal of Maharashtra Agricultural University 22(2) : 168-170.

Solunke R B, Jawale L N, Hussaini M M, Bonde V J and Sudewad S M 1998 Effects of seed treatment on seed health of soybean under storage. Journal of Maharashtra Agricultural University 23(2) : 176-178.

Sunderesh H W and Hiremath P C 1982 Effect of chemical seed treatment on germination and yield of sunflower in Karnataka. Pesticides 16 : 12.

Sushma Nema, Shrivastava A N and Nema S 2003 Effects of new seed dressing fungicides on seedling mortality and yield parameters of soybean. Journal of Mycopathological Research 41(1) : 107-108.

Taywade A S, Potolukhe S R, Shivankar R S, Sonone J S and Naphade R S 2002 Effect of seed dressing chemicals and Rhizobium inoculation on the yield of soybean [Glycine max. (L.) merill]. Legumes Research 25(4) : 297-298.

Thombre P A, Kurundkar B P and Kawale B R 1989 Effect of fungicidal treatments on nodulation and yield of soybean. Journal of Oilseeds Research 6(2) : 353-356.

Tripathi D P and Singh B R 1991 Mycoflora of soybean seed and their control. Madras Agricultural Journal 78(1-4) : 130-132.

* Tylkowska K, Szopinska D and Fieldorow Z 1998 Effects of fungicides and penicillium and Trichoderma spp. on health and germination of onion seed. Roczniki. Akademi Rolniczej W, Poznaniu Agrodnic two 27 : 339-344.

Umesha S, Dharmesh S M, Shelly S A, Krishnappa M and Shelly H S 1998 Biocontrol of downy mildew disease of pearl millet using Pseudomonas flourescens. Crop Protection 17(5) : 387-392.

Vanangamudi K 1988 Storability of soybean seed as influenced by the variety, seed size and storage container. Seed Research 16(1) : 81-87.

Vimala R, Sheela J and Packiaraj D 2000 Management of root rot disease of groundnut by bioagents. Madras Agricultural Journal 87(4-6): 352-354.

* Vrataric M, Sudaric A, Jurkovic D, Culek M and Duvnjak T 2002 Efficiency of applied fungicides on seed and foliar in control of principal soybean diseases. Siemenarstvo 19(1-2) : 33-48.

* Wahid A, Javed M S and Idrees M 1995 Chemical control of fusarium root rot, wilt and collar rot of soybean (*Glycine max*. L.). Pakistan Journal of Phytopathology 7(1) : 21-24.

* Zorato M F and Henning A A 2001 Effect of fungicide seed treatment applied at different storage times on soybean seed quality. Revista Brasileira de sementes 23(2) : 236-244.

Zote K K and Mayee C D 1982 Influence of fungicidal treatment during storage on seed borne fungi. Pesticides 16 : 10-12.

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* Original not seen