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Studies on Seed Quality Parameters of TSP Polymer Coated Ridge Gourd (*Luffa acutangula*) var. PKM 1

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ABSTRACT: The laboratory experiment was conducted in the Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore, during 2021. TSP polymer was synthesized from Tamarind Seed Polysaccharide, to coat and improve the planting value of ridge gourd seeds and replace the use of synthetic polymer for seed coating. The ridge gourd seeds treated with T_0 - Control, T_1 – TSP polymer at 10 g/kg; T_2 – TSP polymer formulation I (TSP-PF-I) at 10 g/kg; T_3 – TSP polymer formulation II (TSP-PF-II) at 10 g/kg and evaluated for its quality parameters. The results revealed that, seeds treated with TSP-PF-II significantly increased the stand establishment traits such as seed germination (86%), speed of germination (30.40), seed metabolic efficiency (10.71), shoot length (21.46 cm), root length (12.05 cm), dry matter production (1.24 g/10 seedlings)and vigour index I (2882) compared to other treatments. It reduced the abnormal seedling (6%), dead seed (8%), days for 50% germination (3.25) and mean emergence time (3.02). Biochemical traits *viz.*, catalase, peroxidase, dehydrogenase, α- amylase activity were maximum in seeds treated with TSP- PF-II. Lowest pathogen infection was observed in seeds treated with TSP- PF-I(1.32%) and TSP- PF-II (1.35%).The results concluded that ridge gourd seeds coated with TSP- PF-II performed better seedling establishment and could be recommended as pre sowing seed treatment.

Keywords: TSP polymer, Seed coating formulation, Tamarind seed polysaccharide, Ridge gourd, Seed quality, Germination.

INTRODUCTION

High-quality seed has the ability to boost farm output and improve food security (Afzal, 2013). Seeds of superior quality are genetically and physically pure, vigorous, and devoid of pests and diseases (Halmer, 2006). Plant uniformity is an expression of potential high seed quality. Farmers and producers are always on the lookout for high-quality seeds to ensure consistent field establishment and higher yield (Ventura *et al.*, 2012).

Seed quality is influenced by several agronomic and environmental factors during seed production *viz.*, successful fertilization, mother crop nutrition, edaphic and environmental conditions during development, maturation, harvesting at physiological maturity, proper drying and post-harvest handling operations.

Quality seed alone contributes 15-20% of increased yield. Apart from production and processing factors, seed quality can be improved/maintained by practicing crops specific enhancement techniques and following good storage practices. Seed enhancements is defined as post-harvest treatments that improve germination or seedling growth or facilitate the delivery of seeds and other materials required at the time of sowing. Seed enhancement is a range of treatments of seeds that improves their performance after harvesting and conditioned, but before they are sown. Seed enhancement include priming, hardening, pregermination, pelleting, encrusting, film coating *etc*, but excludes treatments for control of seed born pathogens (Blackand Peter, 2006; Komala *et al.*, 2018).

Seed coating is defined as the substance applied to seed that does not obscure its shape. Seed coating usually comprises nutrients and seed protectants like fungicides and insecticides (Komala *et al.*, 2018). Film coating, in which the active chemicals are put in a quick-drying polymer and coated around the seed, has gained favor in recent years.

The polymer covering/coating is easy to apply, quickly diffuses and is harmless to seeds during germination. It reduces the chemical wastage, helps to house all required nutrients which aids to improve the physiological potential of seeds besides protecting the seeds from fungal invasion and insect attack. It also protects the seeds from loss of chemical composition during storage. Polymer coating favors the exploitation of fullest potential of the plant protectants by way of preventing dusting and proper adherence of the material on the seed surface. Though beneficial in number of aspects continuous use of synthetic polymers and chemical colorant may increase pollution hazard and may lead to slow degradation of soil, pollute the water and atmosphere and thus effect on crop production, animal and human health.

In recent years, there has been an increase in demand for organic produce, as well as a desire to reduce the use of chemical inputs in agriculture. As a result, much attention has been paid to research into the use of bio/natural materials to substitute chemicals. Organic Agriculture or natural farming is the alternate option to sustain soil health and environment. Organic agriculture is a type of farming that promotes soil, ecological and human health. It focuses on biological processes, biodiversity and cycles that are adapted to local conditions rather than damaging inputs. Chemically treated seeds may not fulfill the requirement of organic agriculture.

The development of plant based seed coating formulations or natural/biopolymers for seed treatments are suitable alternatives to address these issues due to their outstanding properties including good coating/barrier performance, biodegradation ability and low weight.

Biopolymer is a polymerized material which is produced from natural sources or chemically produced from a biological material or biosynthesized by living organisms (Struminska *et al.,* 2014). Polysaccharide based superabsorbent hydrogels have emerged as possible alternatives; they are nontoxic biopolymers that are abundant in nature, usually inexpensive and innately biodegradable and biocompatible (Kamath and Park, 1993). Polymer derived from tamarind seed polysaccharide (TSP) is having good potential as seed coating material which forms very thin film such that without altering the size and shape which aids in identification of species. Tamarind is a commercially important tree that thrives in the dry regions of central and southern India, as well as other Southeast Asian countries (Marathe *et al.,* 2002). The tamarind pulp industry produces tamarind seed as a byproduct (Sagar *et al.,* 2008). Tamarind kernel powder (TKP) is widely used as a sizing material in the textile and food industries. The inclusion of a polysaccharide in TKP gives its sizing capabilities. They are used as adhesives, binding agents, encapsulating agents and swelling agents. The present paper discusses the effect of bio seed coating formulations developed from tamarind seed polysaccharide on seed quality of ridge gourd.

MATERIAL AND METHODS

The laboratory experiment was conducted at the Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India during 2021 to study the effect of biopolymer (TSP polymer) seed coating on seed quality traits. The ridge gourd seeds var. PKM 1 were given with different treatments such as T_0 - Control, T_1 – TSP polymer at 10 g/kg; T_2 – TSP polymer formulation I (TSP-PF-I) at 10 g/kg; T_3 – TSP polymer formulation II (TSP-PF-II) at 10 g/kg. Specified dose of polymer was mixed with 15 ml of water and treated the one kilogram of seeds. Treated seeds were shade dried for one hour and evaluated for seed quality parameters.

Design of the experiment. With five replications, the experiment was done in a completely randomized block design.

Preparation of seed coating TSP polymer. TSP polymer was prepared from defatted tamarind kernel powder as per the process described by Kannan and Manavalan (2007) with some modifications. Tamarind kernel powder defatted by mixing with benzene-ethanol solution (1:1 ratio v/v) at 1:2 ratio w/v and kept for 24 hours and then centrifuged at 10000 rpm for 30 minutes and the supernatants were discarded and the residue was dried in the oven at 40°C. 20g of the defatted tamarind seed kernel powder was mixed with 200 ml of 0.01M hydrochloric acid to and made into a slurry and then slurry was dispersed in 300 ml of boiling 0.01M hydrochloric acid and boiled for 30 minutes at 90^oC in water bath. The slurry was cooled to room temperature, centrifuged at 4000 rpm for 10 minutes and the clear supernatant liquid was collected. From the supernatant, the polysaccharide was precipitated by the addition of equal volume of ethanol. The precipitate was separated by filtration through muslin cloth and dried in hot air oven at 50°C. Dried polysaccharide flakes were powdered with the blender and sieved through 125 μm mesh sieve (sieve number 120) and stored in airtight containers at room temperature for further study.

To prepare polymer, 10 g of Tamarind Seed Polysaccharide (TSP) and one ml of glycerol were dissolved in 200 ml of water by stirring with a mechanical stirrer at 2000 rpm. After complete dissolution of the polysaccharide 4 g of agar dissolved with the solution and heated to about 90°C in water bath for 15 minutes. The solution was cooled at room temperature and stored in refrigerator.

Preparation of TSP polymer formulations. The components of the formulations are described below:

Components of TSP polymer formulation I (100 g)	
1. TSP polymer	100 g
2. Natural preservative- lime juice (100%)	2 ml
3. Humic acid (HA)	5 g
4. Zimmu leaf extract (100%)	5 ml

Components of TSP polymer formulation II (100 g)	
1. TSP polymer	100 g
2. Natural preservative -lime juice (100%)	2 ml
3. Humic acid (HA)	5 g
4. Zimmu leaf extract (100%)	5 ml
5. Ascorbic acid (AsA)	2 g

Lime juice was extracted from fully ripen lemon and centrifuged at 5000 rpm for 10 minutes and supernatant used as a natural preservative. Humic acid and Ascorbic acid were purchased from Sigma-Aldrich Chemical Co., Bangalore, India. Zimmu leaf extract was prepared by taking ten gram of fresh leaves and thoroughly washed with distilled water. The leaves were ground well with sterile distilled water (1:10) using a pestle and mortar. The extract was filtered through a muslin cloth and filtrate was centrifuged at 10,000 rpm for 15 minutes. The supernatant served as the standard leaf extract solution.

Seed coating. Polymer dose for ridge gourd seed was fixed as 10 g/kg (10 g of polymer mixed with 15 ml of distilled water to coat one kg of seeds) based on preliminary study. Along with TSP polymer different active ingredients were mixed and coated on seed. Treated seeds were shade dried for one hour and evaluated for seed quality parameters.

Observations

(a) Seed physical traits

(i) Seed moisture content and ii. 100 seed weight. Seed moisture content and 100 seed weight was estimated as per the protocol in the seed testing manual (ISTA, 2013)

(b) Stand establishment traits

(i) Seed germination (%). The standard germination test was conducted in the laboratory by using sand media as per ISTA (ISTA, 2013). After 14 days of germination, the number of normal seedlings produced was counted and germination percentage (GP) was calculated, according to the formula:

Germination percentage (GP) = (Ng / Nt) × 100

Where Ng is a total number of normal seedlings germinated, Nt is a total number of seeds evaluated.

(ii) Days for 50 per cent germination and iii. Days for maximum germination. In the sand media, the number seeds germinated was recorded daily up to final count and number of days required for 50 per cent germination and maximum germination was computed according to the protocol of Heydecker and Coolbear (1977); Mauromicale and Cavallaro (1995) respectively.

(iii) Speed of germination. Numbers of seeds germinated were counted daily up to 14 days at the same time of day and speed of germination was calculated as per the protocol described by Magiure (1962).

(iv) Mean germination time. Germinated seeds were recorded daily up to 14 days at the same time of day. Mean germination time (MGT) was calculated according to Bailly *et al.* (2000) using the formula:

$$\text{MGT} = \frac{\Sigma\ (\text{Dn})}{\Sigma \text{n}}$$

Where, n is the number of seeds germinated on each day and D is the day of counting

(v) Endosperm and embryo degradation (Seed Metabolic Efficiency). Amount of seed respired (SMR) was calculated by using the formula

SMR = Seed dry weight before germination-(Seedling dry weight + Remaining seed dry weight)

Seed Metabolic Efficiency (SME) was calculated using the formula (Rao and Sinha, 1993)

$$\text{SME} = \frac{\text{Seedling dry weight}}{\text{SMR}}$$

(vi) Root length and shoot length (cm). Ten normal seedlings from the standard germination test were randomly selected and the root and shoot length was measured from the collar region to the tip of the primary root and tip of the shoot respectively. The average value was expressed in centimeter.

(vii) Drymatter production (g seedlings^{-10}) and ix. Total dry matter production (g). The seedlings used for growth measurement and remaining normal seedlings were placed in a butter paper cover separately and dried in shade for 24 h and then kept in an oven maintained at 85 ± 2^{o}C for 24 h. Dry weight was recorded and the mean values were expressed in g.

(viii) Vigour index I and II. Vigour index values were computed using the formula given by Abdul-Baki and Anderson (1973) and the mean values were expressed in whole number.

(c) Biochemical traits

(i) Dehydrogenase activity (OD value). Dehydrogenase activity of twenty five preconditioned seeds from each treatment wasestimated as per the protocol given by Kittock and Law (1968).

(ii) α – amylase activity (mg maltose min^{-1}). α – amylase activity was estimated based on the procedure given by Simpson and Naylor, 1962.

(iii) Catalase activity (Sinha, 1972). Catalase activity was measured by an assay of hydrogen peroxide (Sinha, 1972).

(iv) Peroxidase activity (ΔOD 430 mg^{-1} min^{-1}). Peroxidase activity was estimated as per the procedure described by Singh *et al.*, 1980.

(d) Seed health

(i) Pathogen infection. The pathogen infection test was carried out as per the procedure prescribed by ISTA, 2013.

Data analysis. Statistical analyses of the experimental data were performed using the SPSS software (ver. 18.0). All of the data presented are the averages of five replicates, with deviations calculated as the standard error of the mean (SEM). Analysis of variance (ANOVA) was used for statistical processing. Duncan test post hoc analysis was performed to define which specific mean pairs were significantly different. A significant level was defined as a probability of 0.05 or less.

RESULTS AND DISCUSSION

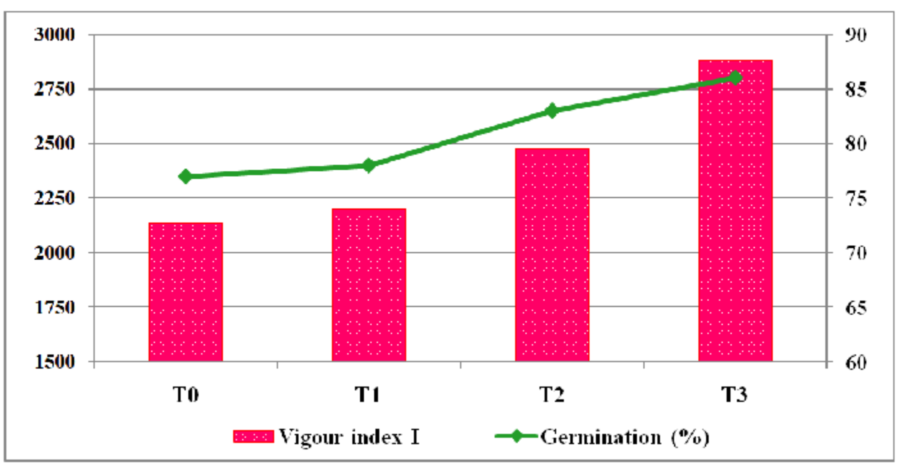
In the present study, ridge gourd seeds were treated with TSP polymer, TSP-PF-I and TSP-PF-II. Untreated seeds served as a control. Treated and control seeds were analyzed for physical, physiological, biochemical and health parameters. The objective of the present study was to evaluate the effect of TSP polymer, and combination of TSP polymer and additives to improve the planting value of ridge gourd seeds.

A. Physical parameters

The result showed that, non-significant differences for seed physical parameters *viz.,* seed index and seed moisture content among the seed treatments. Polymer coating formed very thin film around the seeds without obscuring its shape and total seed weight, hence it did not increase the seed weight significantly (Table 1). Polymer treatment did not alter the seed moisture content significantly (Table 1), because treated seeds were dried under shade before analyzing the seed quality parameters. These results are in conformity with the results of Mahantesh *et al.* (2017) in cotton and John *et al.* (2005) in maize.

B. Physiological parameters

Among the treatments, TSP-PF-II significantly increased the seed germination (86%) and reduced the abnormal seedling (6%) and dead seed (8%) percentage compared to control (77, 12 and 11% respectively) and other treatments (Fig. 1 and Table 1). Seeds treated with TSP polymer shows non-significant difference with control. While TSP polymer added with additives exhibited improved physiological parameters. The improved germination and reduced abnormal seedling in TSP-PF-II may be due to the plant growth promoting substances present in the polymer. HA or AsA or both may involve in increased growth. As quoted by Nikbakht *et al.* (2008), HA is a cell elongation factor, which enhances the cell division and elongation, promotes the root development and nutrient uptake. Abnormalities that are caused by various situations *viz.,* lack of food reserves, mechanical damage, adverse environmental condition during development, improper storage and physiological ageing. Here HA supplies both micro and macro nutrient; AsA scavenges the free radicle which developed during storage and promotes germination and reduces the abnormal seedling and dead seeds.



T_0 - Control, T_1 TSP polymer at 10 g/kg; T_2 TSP polymer formulation I (TSP-PF-I) at 10 g/kg; T_3 TSP

T_0 - Control, T_1 – TSP polymer at 10 g/kg; T_2 – TSP polymer formulation I (TSP-PF-I) at 10 g/kg; T_3 – TSP polymer formulation II (TSP-PF-II) at 10 g/kg

Fig. 1. Effect of TSP polymer and its formulations on germination and seedling vigour of ridge gourd.

Table 1: Effect of TSP polymer and its formulations on stand establishment traits of ridge gourd.

Treatments	100 seed weight (g)	Seed moisture content (%)	Abnormal seedling (%)	Dead seeds (%)	Days for 50 per cent germination	Speed of germination	Mean emergence time
T_0	17.41	7.12	12	11	4.25	21.84	4.07
T_1	17.76	7.15	11	11	4.00	23.67	3.82
T_2	17.72	7.16	9	8	3.75	26.97	3.15
T_3	17.78	7.14	6	8	3.25	30.40	3.02
Mean	**17.67**	**7.14**	**9.5**	**9.5**	**3.81**	**25.72**	**3.56**
SEd	**NS**	**NS**	**0.000**	**0.000**	**0.042**	**0.187**	**0.034**
CD (P=0.05)	**NS**	**NS**	**0.000**	**0.000**	**0.088**	**0.396**	**0.073**

T_0 - Control, T_1 – TSP polymer at 10 g/kg; T_2 – TSP polymer formulation I (TSP-PF-I) at 10 g/kg; T_3 – TSP polymer formulation II (TSP-PF-II) at 10 g/kg

Sabzevari *et al.* (2009); Prakash *et al.* (2014); Mosapour *et al.* (2014) found that HA increased the germination rate in wheat, radish and marigold respectively. Because of its low molecular weight, HA was easily absorbed by the seed, increasing the absorption of nutrients such as nitrogen and phosphorus (Asenjo *et al.*, 2000) and stimulating seed germination (Asgharipour and Rafiei, 2011; Basalma, 2015).

The mechanism of HA's effect on seed germination is unclear; nevertheless, two effects are mentioned in certain resources: HA has a direct (production and function of plant growth hormones) and indirect (improved absorption of nutrients) influence on seed germination (Nardi *et al.*, 2002).

The germination improvement in TSP-PF-II may also be due to added ASA. Hydrogen peroxide, superoxide species, and other free radicals are detoxified by ASA, a water-soluble antioxidant. It also plays an important function in plant growth processes such as cell division and cell wall expansion (Azooz, 2013). Some germination indicators are improved by seed treatment with ASA, such as germination percentage, mean germination time (MGT), seedling fresh and dry weight in cumine (Ghiyasi *et al.*, 2015), cowpea (Nunes *et al.*, 2020) and pea (Burguieres *et al.*, 2007). AsA ameliorates the germination percentage and speed of germination in wheat (Khan *et al.*, 2020), sunflower, rape seed (Dolatabadian and Modarres Sanavy, 2008) and soybean (Ramya, 2015). AsA improves seed germination by acting as a cofactor in the biosynthesis of many plant hormones, including ethylene, gibberellic acid (GA), and abscisic acid (ABA), as well as maintaining the process of phytohormone mediating signalling (Barth *et al.*, 2006). It also plays a role in several plant physiological processes (Farooq *et al.*, 2013). AsA is also involved in photosynthesis, hormone manufacturing, and antioxidant renewal, as well as controlling cell division and growth (Conklin and Barth, 2004).

Speed of germination, shoot length, root length, drymatter production, vigour index Iand vigour index II significantly increased by TSP-PF-II (30.40, 21.46 cm, 12.05 cm, 1.24 g, 2882 and 106.64 respectively) compared to other treatments (Table 1, 2 and Fig. 1). It also significantly increased the Seed Metabolic Efficiency (SME) (Table 2). The amount of shoot and root drymatter (g) produced from 1 unit (g) of dry seed weight respired is known as SME. As a result, the greater the value of seed metabolic efficiency, the more efficient the seed is, as more seed reserves are employed to produce roots and shoots. The production of more vigorous seedlings in TSP-PF-II treated seeds may be due to added HA substances or AsA or combination of both. HA treatment increased the root fresh weight and length in cucumber, squash, marigold and geranium (Hartwigsen and Evans, 2000). Sabzevari *et al.* (2009) demonstrated that HA increased the seed vigor index of *Triticum aestivum* significantly. HA increases the length of root and shoot, increases the fresh and dry weight of root and shoots (Hartwigsen and Evans, 2000 in pea; Asgharipour and Rafiei, 2011 in barley; Basalma, 2015 in safflower; Rodrigues *et al.*, 2017 in corn) and increases the cell elongation (Smiri*et al.*, 2015) in peas.

T_0 - Control, T_1 – TSP polymer at 10 g/kg; T_2 – TSP polymer formulation I (TSP-PF-I) at 10 g/kg; T_3 – TSP polymer formulation II (TSP-PF-II) at 10 g/kg

Fig. 2. Effect of TSP polymer and its formulations on stand establishment of ridge gourd.

Table 2: Effect of TSP polymer and its formulations on seedling vigour parameters of ridge gourd.

Treatments	Seed metabolic efficiency	Shoot length (cm)	Root length (cm)	Dry matter production (g/10 seedlings)	Total dry matter production (g)	Vigour index II
T_0	3.43	18.42	9.27	1.01	8.03	77.77
T_1	3.01	18.83	9.39	1.05	8.46	81.9
T_2	4.55	19.74	10.12	1.18	9.63	97.94
T_3	10.71	21.46	12.05	1.24	10.56	106.64
Mean	**5.43**	**19.61**	**10.21**	**1.12**	**9.17**	**91.06**
SEd	**0.040**	**0.229**	**0.107**	**0.007**	**0.116**	**0.968**
CD (P=0.05)	**0.085**	**0.485**	**0.227**	**0.014**	**0.245**	**2.052**

T_0 - Control, T_1 – TSP polymer at 10 g/kg; T_2 – TSP polymer formulation I (TSP-PF-I) at 10 g/kg; T_3 – TSP polymer formulation II (TSP-PF-II) at 10 g/kg

Cordeiro *et al.* (2011) investigated the influence of humic acid on maize root growth and discovered that humic acid promoted root development and enhanced the fresh-dry weight ratio of corn roots. The enhanced seedling length and dry weight is due to HA increasing chlorophyll pigments and hence increasing photosynthesis. According to Ghasemi *et al.* (2012), HA raises the chlorophyll pigment, which increases the photosynthetic rate and efficiency, which could be the explanation for the seedlings higher weight. In the presence of humic acids, absorption of macro elements (N, P, K, Mg, Ca) and micro-elements (Cu, Fe, Zn.) increased and also improved fertility and mineral reserves by dissolution of macro elements, which promotes seedling growth (Canellas *et al.*, 2002).

The non-enzymatic antioxidant AsA can protect plant tissues from the damaging effects of reactive oxygen species (ROS) (Kibinza *et al.,* 2006). AsA activity results in high levels of resistance to oxidative damage and decreases cell damage (Tabatabaei, 2015). Onion seeds treated with AsA, alpha to copherol and glutathione had the best germination, speed of germination, seedling dry weight, and seedling vigour index, according to Varun Kumar *et al*. (2020).

TSP-PF- II significantly reduced the mean emergence time and days for 50% germination (3.02 and 3.25) compared to remaining treatments (Table 1). The results of Canellas and Facanha (2004) revealed that the application of HA in soybean increased its water absorption, germination rate and respiration and decreased the mean germination time.Sabzevari *et al.* (2009) studied the effect of humic acid on the germination of spring wheat and demonstrated that HA decreased germination mean time. AsA reduced the mean emergence time and time to 50% germination in wheat (Khan *et al.*, 2020), sunflower, rape seed (Dolatabadian and Modarres Sanavy, 2008) and soybean (Ramya, 2015).

C. Biochemical parameters

Seeds treated with TSP-PF-II was significantly increased the antioxidant enzyme activity such as catalase (66.78 µg H_2O_2/min/mg protein) and peroxidase (3.73 ΔOD 430 mg^{-1} min^{-1}) activity compared to control (54.28 µg H_2O_2/min/mg proteinand 3.13 ΔOD 430 mg^{-1} min^{-1} respectively). Non-significant difference was observed in other treatments compared to control (Table 3).

Dehydrogenase and α-amylase enzyme activity was more in seed treated with TSP-PF-II (3.21 OD value and 14.23 mg maltose min^{-1}) compared to other treatments and control (Table 3). This may be due to As A present in the polymer. Ascorbic acid induces the up-regulation of diverse antioxidant enzymes such as super oxide dismutase, peroxidase and catalase in wheat (Shah *et al.*, 2019).

Table 3: Effect of TSP polymer and its formulations on biochemical parameters and pathogen infection of ridge gourd.

Treatments	Peroxidase (ΔOD 430 mg^{-1} min^{-1})	Catalase (µg H_2O_2/min/mg protein)	α-amylase (mg maltose min^{-1})	Dehydrogenase (OD value)	Pathogen infection (%)
T_0	3.13	54.28	12.45	2.74	4.04
T_1	3.17	54.43	12.53	2.72	4.27
T_2	3.18	54.52	12.52	2.74	1.32
T_3	3.73	66.78	14.23	3.21	1.35
Mean	**3.30**	**57.50**	**12.93**	**2.85**	**2.75**
SEd	**0.033**	**0.771**	**0.160**	**0.031**	**0.029**
CD (P=0.05)	**0.070**	**1.635**	**0.339**	**0.065**	**0.061**

T_0 - Control, T_1 – TSP polymer at 10 g/kg; T_2 – TSP polymer formulation I (TSP-PF-I) at 10 g/kg; T_3 – TSP polymer formulation II (TSP-PF-II) at 10 g/kg

Varun Kumar *et al.* (2020) discovered that onion seeds treated with antioxidants such ascorbic acid, alpha tocopherol, and glutathione had the maximum activity of the dehydrogenase enzyme and alpha amylase enzyme. Alfalfa seed treatment with AsA improves alpha amylase activity (Chen *et al.,* 2021). Seed priming with ascorbic acid greatly boosted the activity of peroxidase in wheat and maize seed, according to Moori and Esivand (2017) and Ahmad *et al.* (2012). Razaji *et al.* (2012) discovered that under drought stress, As A greatly increased the catalase and peroxidase activity of safflower.

iv. Pathogen infection

The results shows that the seeds treated with TSP-PF-I and TSP-PF-II significantly reduced the pathogen infection (1.32 and 1.35% respectively) compared to TSP polymer treated seeds (4.27%) and untreated control (4.0%) (Table 3). This may be the reason for reduced seed death in TSP-PF-I and TSP-PF-II. Reduced pathogen infection is due to antimicrobial agent (zimmu leaf extract) added to the TSP-PF- I and TSP-PF-II. Satya *et al.* (2005) found that the leaf extract of zimmu showed the maximum antifungal activity against *Rhizoctonia solani* and it also effective in inhibiting the growth of other fungal and bacterial pathogens *viz., Aspergillus flavus, Alternaria solani, Curvularia lunata, Xanthomonas campestris* pv. *Malvacearum, X. oryzae* pv. *oryzae,* and *X. oxonopodis* pv. *citri*.

CONCLUSION

TSP polymer and its formulations hada significant effect on physiological and biochemical seed quality traits in ridge gourd. TSP-PF- II improved the stand establishment such as seed germination, speed of germination, seed metabolic efficiency, shoot length, root length, drymatter production, vigour index I and vigour index II compared to other treatments. TSP-PF-II increased the dehydrogenase and α- amylase activity. It also showed maximum antioxidant enzyme activity such as catalase and peroxidase. It reduced the days for 50 % germination, mean germination time and pathogen infection compared to control. Thus the study highlighted that seeds coated with tamarind seed polysaccharide polymer formulation II improved the seed quality characteristics in ridge gourd. The present study was conducted in the lab conditions; further studies could be done to investigate the effect of TSP polymer and its formulations in the field conditions.

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Conflict of Interest. None.

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