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RESEARCH ARTICLE

Seed Invigouration Techniques for Enhancing the Field Emergence, Crop Growth and Productivity of Ridge gourd (*Luffa acutangula* L.)

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Abstract

A field experiment was conducted to evaluate the effect of seed invigouration techniques such as seed priming and seed coating on crop growth, sex expression and crop productivity of ridge gourd. The seeds of ridge gourd were subjected to a schedule of seed invigouration techniques which included seed priming and seed coating with TNAU seed coating formulations. The seeds subjected to various treatments were sown in the field and observations were made on field emergence, crop growth, sex expression as well as yield attributing factors.The results revealed that irrespective of the treatments, significant effect was observed in field emergence (%), vine length (cm), number of leaves plant^{-1}, number of branches plant^{-1}, leaf chlorophyll content and leaf area index, compared to control. Among the treatments, highest improvement in all the growth parameters was observed in 'seed priming + seed coating formulation II @ 4g kg^{-1}'. Concomitant to the vigourous plant growth recorded in 'seed priming + seed coating formulation II @ 4g kg^{-1}', there was an early initiation of male (31.77th day) and female flowers (36.75th day). This treatment also recorded higher number of female flowers plant^{-1} (13.78) resulting in higher number of fruits (10.78) as well as higher number of seeds per fruit (90.07). The corresponding values recorded by control seeds were 11.56, 9.56 and 85.55, respectively. The higher number of seeds as well as 100 seed weight ultimately resulted in higher seed yield plot^{-1} of 4.36 kg with this treatment while the control recorded only 3.52 kg/plot. The results endorsed that maximum effect of seed invigouration can be obtained by subjecting the seeds to 'seed priming + seed coating with brassinosteroid based 'TNAU seed coating formulation II @ 4g kg^{-1}', in order to obtain higher crop growth and yield.

Keywords: *Ridge gourd, Brassinosteroid, Seed coating formulation, Field emergence, Seed priming, Crop growth, Sex expression, Crop productivity*

Introduction

Ridge gourd (*Luffa acutangula* L.) is popularly known as angled gourd, angled loofah, chinese okra, silky gourd and ribbed gourd. Ridge gourd belongs to genus *Luffa* of Cucurbitaceae and has a chromosome number of 2n = 26. Ridge gourd originated in India and it exhibits wide genetic variation for various morphological fruit characteristics. Green fruits are cooked as vegetable. Fruit contains protein (0.5%), carbohydrate (3%), carotene (37 mg) and vitamin C (18 mg) per 100 g of edible portion (Thamburaj and Singh, 2013). It is a popular vegetable both as spring summer and rainy season crop. It is cultivated in India, Indonesia, Malaysia, Myanmar, Philippines, Sri Lanka and Taiwan.

Seed is considered as one of the most important basic agricultural input for obtaining higher yield. Good quality seed acts as a catalyst for realizing the potential of all other inputs in agriculture. Without good seed, the investment on fertilizer, water, pesticides and other inputs will not pay the desired dividends. Seed invigouration treatments are physiological treatments that imply an improvement in physiological status of seed, thereby achieved improved germinability, greater storability and better performance than the corresponding untreated seeds (Basu, 1979). Seed priming is a technique wherein seeds are hydrated to a level below that is needed for radicle emergence, so as allow the pre-germinative metabolism to proceed, later dried to the original moisture

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content (McDonald, 2000) to fix all the metabolic changes that had occured. In the last two decades, seed priming, has become a common seed technique to increase the rate and uniformity of emergence and crop establishment in most crops especially in advanced countries to obtain increased seed germination percentage, better speed of emergence and improved tolerance to abiotic stress (Karimmojeni *et al.,* 2012).

Seed coating technology has developed rapidly during the past two decades and provides an economical approach to seed enhancement, especially for larger seeded agronomic and horticultural crops. A new gibberellic based 'seed coating formulation' had been developed in Tamil Nadu Agricultural University (Karthi, 2017) with a significant augmentary effect on seed germination and seedling growth characteristics of many crop seeds. In order to harness the maximum invigouration potential of both seed priming and seed coating, a study was conducted to analyse the effect of different combinations of seed priming and seed coating with new seed coating formulations on field emergence, crop growth, sex experssion and crop productivity of ridge gourd.

In the present study, ridge gourd seeds were subjected to seed priming, seed coating with gibberellic acid and brass inosteroid based seed coating formulations and subjected to a field study to assess the crop growth and productivity.

Material and Methods

Genetically pure, ridge gourd seeds var. PKM 1 (*Luffa acutangula* L.) was obtained from Department of Vegetables, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. Synthetic polymers and pigment obtained from Sudarshan General Traders, Sivakasi, served as the base material for preparing the seed coating polymer formulation. The composition standardized through preliminary experiments were mixed and homogenized to produce two seed coating polymer formulations (SCF). Seed coating formulation I (SCF I) was prepared using gibberellic acid, carboxy methyl cellulose, polymer and red pigment (Karthi, 2017) while seed coating formulation II (SCF II) was preapred by replacing gibberellic acid with brassinosteroid, while retaining all other components as such.

The newly developed seed coating polymer formulations were taken up for coating of ridge gourd seeds in combinations involving seed priming. The treatments imposed were,

T_0- Control; T_1- Seed priming; T_2- SCF I - @ 4 g kg^{-1}; T_3- SCF II- @ 3 g kg^{-1}; T_4- SCF II- @ 4 g kg^{-1}; T_5- Seed priming + SCF I- @ 4 g kg^{-1}; T_6- Seed priming + SCF II- @ 3 g kg^{-1}; T_7- Seed priming + SCF II- @ 4 g kg^{-1} with 7 ml of water.

Seed coating: Known quantity of seeds were taken in a beaker and seed coating formulation was poured over the seeds after diluting with water and stirred continuously to ensure uniform coating over the seeds. Coated seeds were shade dried immediately.

Seed priming: A known volume of seeds were packed separately in closely woven individual cloth bags and placed in priming bin. Water was filled in the priming bin of the seed priming machine automatically. Once the water was filled, seeds packed in cloth bags were allowed to soak in 24 hours. The soaking duration was previously standardized by Soon *et al* (2000). On completion of the soaking period, water was completely drained from the priming bin automatically by pressing the 'SPIN' button. The soaked seeds were subjected to 'Spin drying' for previously standardized durations for ridge gourd (5 min) (Chandan, 2017).

The spin primed seeds were shade dried at room temperature to bring back to the original moisture content. The seeds coated with seed coating formulation II in different dosages (3g and 4g/kg), along with seed coating formulation I (4g/kg) were subjected to field studies at the Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore during 2017-2018.

Subsequently, seeds invigourated as per the treatment schedule were sown in field by following Randomized Block Design with 4 replications. The crop was grown by following recommended package of practices. During the crop growth period, periodically ten plants in each replication and treatments were randomly selected for recording the growth parameters *viz.,*vine length (cm), number of leaves plant^{-1}, number of branches plant^{-1}, leaf chlorophyll content and leaf area index and yield parameters *viz.,* no. of fruits/vine, length (cm), grith (cm), weigth (g) of fruit, fruit yield ha^{-1} and seed recovery (%).

Results and Discussion

The objective of the experiment was to evaluate the effect of seed priming and seed coating formulation on crop growth, sex expression and yield attributes and crop productivity of ridge gourd. The treatments included seed priming, seed coating formulation I, seed coating formulation II @ 3g kg^{-1}, seed coating formulation II @ 4g kg^{-1}, Priming + seed coating formulation I, Priming + seed coating formulation II @ 3g kg^{-1} and Priming + seed coating formulation II @ 4g kg^{-1}. Among the treatments the higher field emergence

(%) was recorded in 'seed priming + formulation II @ 4g kg^{-1}' (68%) while the control recorded only 58 per cent (Table 1).

Table 1. Effect of seed invigouration treatments on crop growth of ridge gourd var. PKM1

Treatments	Field emergence (%)	Vine length (cm) (40 DAS)	No. of leaves / plant (40 DAS)	No. of branches / plant (40 DAS)	Leaf chlorophyll content (SPAD value)	Leaf area index (LAI)
Control	58 (49.60)	100.5	11.33	1.72	28.77	1.58
Seed Priming	64 (53.13)	132.4	12.35	2.23	30.15	1.66
SCF I	60 (50.77)	104.8	11.43	1.76	28.43	1.60
SCF II – 3g/kg	63 (52.54)	127.7	12.41	1.88	29.58	1.64
SCF II – 4g/kg	62(51.94)	139.0	12.75	2.21	31.54	1.70
Seed Priming + SCF I	65 (53.73)	147.2	13.55	2.43	30.77	1.66
Seed Priming + SCF II -3g/kg	62 (51.94)	154.3	13.72	2.04	29.59	1.62
Seed Priming + SCF II -4g/kg	68 (55.55)	158.9	13.77	2.46	32.08	1.79
Mean	63 (52.54)	133.1	12.66	2.09	30.11	1.65
SEd	0.48	1.88	0.15	0.03	0.42	0.02
CD (P=0.05)	1.01	3.92	0.33	0.06	0.88	0.04

(Figures in parenthesis indicate arcsine values)

*SCF- Seed coating formulation

Venketasubramaniam and Umarani (2004) reported that hydro priming of tomato for 48 h, sand matri priming of brinjal and chilli in 80% WHC for 3 days resulted in significant improvement of seed germination and seedling vigour. Nirmala and Umarani (2008) observed that 3 h of sand matri priming of okra in 60% WHC and 12 h of hydropriming of beet root enabled the seeds to attain highest improvement in seed germination, speed of germination and seedling vigour. Thus in the present study the higher field emergence of ridge gourd could have resulted due to invigouration of seeds due to seed priming treatment.

Table 2. Effect of seed invigouration treatments on sex expression in ridge gourd var. PKM1

Treatments	1st male flower initiation	1st female flower initiation	50 % male flowering	50 % female flowering	No. of male flowers / vine	No. of female flowers / vine	Sex ratio
Control	34.08	40.55	43.89	52.07	99.14	11.56	8.6
Seed Priming	32.12	37.26	40.82	48.48	104.81	12.54	8.4
SCF I	33.49	38.59	42.19	48.72	104.79	12.43	8.4
SCF II – 3g/kg	33.10	37.76	41.70	48.41	105.61	12.26	8.6
SCF II – 4g/kg	32.09	37.22	40.59	48.16	105.72	12.68	8.3
Seed Priming + SCF I	32.16	37.11	40.55	47.95	105.21	13.42	7.8
Seed Priming + SCF II - 3g/kg	32.21	37.18	39.71	47.88	104.18	12.98	8.0
Seed Priming + SCF II - 4g/kg	31.77	36.75	38.87	47.64	106.59	13.78	7.7
Mean	32.62	37.80	41.04	48.66	104.51	12.71	8.2
SEd	0.52	0.31	0.47	0.72	1.21	0.13	0.07
CD (P=0.05)	1.08	0.65	0.99	1.50	2.52	0.28	0.16

*SCF- Seed coating formulation

Besides, the seeds coated with seed coating with brassinosteroid based seed coating formulation II, might have also benefited due to the infusion of brassinosteroid into the seed, during the seed imbibition process of seed germination. The positive role of brassinosteroid has been reported in many crop species, either as seed treatment or folair spray. BRs stimulate the mitotic activity of apical root meristem cells to induce the root growth resulting in better seedling establishment (Allagulova *et al.*, 2015; Rattan *et al.*, 2017).

The vine length recorded in control plants of ridge gourd was 100.5 cm (40 DAS), while highest value of 158.9 cm was recorded in 'seed priming + formulation II @ 4g kg^{-1}'. Among the treatments, number of leaves was found to be highest in 'seed priming + formulation II @ 4g kg^{-1}' at 40 DAS (13.77). Similarly number of branches $plant^{-1}$, was also observed to be highest in 'seed priming + formulation II @ 4g kg^{-1}' (2.46), while the control recorded only 1.72 branches. The ridge gourd seeds coated with brassinosteroid based seed coating formulation (II) substantially improved the vegetative growth of the plants as reflected in the increase of all growth parameters recorded in this study (Table 1).

Table 3. Effect of seed invigouration treatments on fruit characteristics on ridge gourd var. PKM1

Treatments	Fruits / vine	Weight (g)	Length (cm)	Girth (cm)	Yield / ha (kg)	Seed recovery %
Control	9.56	84.42	36.47	20.09	3590	10 (18.43)
Seed Priming	10.25	88.11	38.34	19.56	4010	12 (20.27)
SCF I	10.11	88.09	38.09	19.08	3960	11(19.37)
SCF II – 3g/kg	10.06	87.75	38.59	19.19	3920	12 (20.27)
SCF II – 4g/kg	10.34	88.35	39.21	19.86	4060	12 (20.27)
Seed Priming + SCF I	10.43	88.46	38.21	20.93	4100	13 (21.13)
Seed Priming + SCF II - 3g/kg	10.50	89.65	38.07	20.87	4180	13 (21.13)
Seed Priming + SCF II - 4g/kg	10.78	90.91	39.35	21.90	4360	13 (21.13)
Mean	10.25	88.22	38.29	20.19	4.02	12 (20.27)
SEd	0.15	1.21	0.46	0.23	0.06	0.12
CD (P=0.05)	0.31	2.52	0.96	0.48	0.13	0.25

(Figures in parenthesis indicate arcsine values)

*SCF- Seed coating formulation

The improvement in plant growth parameters of ridge gourd plants subjected to seed coating with brassinosteroid based formulation (II) might be due to stimulation of cell division and cell enlargement culminating in better growth and development of plants (Schneider, 2004).

The leaf chlorophyll content was found to be lowest in control (28.77), while it was highest in 'seed priming + formulation II @ 4g kg^{-1}' (32.08). The corresponding leaf area index was 1.58 and 1.79, respectively. The observations on all the crop growth parameters revealed that 'seed priming + seed coating with formulation II @ 4g kg^{-1}' was significantly superior to control as well as rest of the treatments (Table 1). The effect of brassinosteroid on chlorophyll content of plants has been reported in other crops. Foliar application of 24- epi-brassinolid improved the chlorophyll content, chlorophyll florescence, net photosynthetic rate in *Cucumis melo* (Zhang *et al.*, 2014). Khan *et al.* (2015) reported that brassinosteroid application improved photosynthetic activity, chlorophyll content, and membrane integrity of tomato plants.

The observations made on sex expression parameters of ridge gourd are discussed here under. The days taken for 1^{st} male flower initiation was found to lowest in 'seed priming + formulation II @ 4g kg^{-1}' (31.77 DAS), while it took 34.08 DAS for control seeds. Similarly in the case of female flowers, the flower initiation took place on 36.75 DAS in 'seed priming + formulation II @ 4g kg^{-1}', while it took 40.55 DAS in control. The days to 50% flowering of male flowers (38.87) and female flowers (47.64) was also lowest in plants subjected to 'seed priming + formulation II @ 4g kg^{-1}', when compared to all other treatments as well as control (Table 2).

The number of male (106.59) and female flowers $vine^{-1}$ (13.78) was also found to be highest in the same treatment, which was 7 and 19 per cent higher than control. Ultimately, the sex ratio (male : female) was observed to be lowest in 'seed priming + formulation II @ 4g kg^{-1}' by recording 12 per cent reduction over control (Table 2).

The increase in number of female flowers due to application of brassinosteroid has been reported by many researchers (Papadopoulou and Grumet, 2005; Manzano *et al.,* 2011). Papadopoulou and Grumet (2005) reported that "application of epi-BL to monoecious cucumber plants caused earlier flowering and increased production of female buds, indicating a possible involvement of brassinosteroids in floral sex differentiation in cucumber". Brassinosteroid might have influenced the plant function indirectly by increasing ethylene production. This hormone has been reported to increase the ethylene biosynthesis in mung bean, Arabidopsis and tomato (Arteca and Arteca, 2001).

The effect of seed priming and seed coating formulation on fruit characteristics of ridge gourd was studied by observing number of fruits vine^{-1}, fruit weight (g), fruit length (cm) and fruit girth (cm). The data revealed the superiority 'priming + formulation II @ 4g kg^{-1}' treatment, which enabled highest improvement in fruit characteristics. This treatment recorded the highest values of 10.78, 90.91 g, 39.35 cm and 21.9 cm, respectively for number of fruits vine^{-1}, fruit weight (g), fruit length (cm) and fruit girth (cm). The corresponding values recorded by control were 9.56, 84.42 g, 36.74 cm and 20.09 cm, respectively. The improvement in the fruit characteristics eventually resulted in higher fruit yield kg plot^{-1} in 'seed priming + formulation II @ 4g kg^{-1}' (29.4 kg plot^{-1}) and fruit yield hectare^{-1} (4.36 t). The percentage increase in fruit yield obtained with this treatment was 21 % over control (Table 3).

Table 4. Effect of seed invigouration treatments on seed characteristics on ridge gourd var. PKM1

Treatments	No. of seeds / fruit	Seed weight / fruit (g)	100 seed weight (g)	Seed yield / ha (kg)
Control	85.55	12.27	15.22	521.28
Seed Priming	88.35	13.08	15.42	595.81
SCF I	88.19	12.67	15.45	569.24
SCF II – 3g/kg	87.43	12.96	15.36	579.39
SCF II – 4g/kg	88.49	13.15	15.49	604.25
Seed Priming + SCF I	89.08	12.79	15.78	592.82
Seed Priming + SCF II - 3g/kg	89.45	13.21	16.04	616.41
Seed Priming + SCF II - 4g/kg	90.07	13.49	16.24	646.25
Mean	88.33	12.95	15.63	590.68
SEd CD (P=0.05)	1.23 2.56	0.14 0.31	0.20 0.43	8.19 17.03

*SCF- Seed coating formulation

BR have a significant role in reproductive development of plants (Clouse and Sasse, 1998). Wu *et al.* (2008) reported that foliar application of BR increased the number of fertile tillers hill^{-1} in rice.

Ali *et al.* (2006) reported an increase in the number, size and weight of fruits besides improvement in carotene content. Ramesh *et al.* (2013) reported that the application of brassinosteroid (25 ppm) at flower initiation stage alone resulted in higher seed yield of soybean. Application of brassinolide (0.5 ml/l) at budding + flowering stages significantly recorded higher yield attributes and yield as compared to brassinolide spraying at budding stage alone.

The effect of 'seed priming+ seed coating formulation II @ 4g kg^{-1}' on seed characteristics of ridge gourd were observed in terms of number of seeds fruit^{-1}, seed weight fruit^{-1} (g) and 100 seed weight (g). All the parameters were found to be lowest in control plants by registering, 85.55, 12.27 g, and 15.22 g, respectively. The ultimate effect was found on seed yield (kg plot^{-1}) (3.52 kg). However, the highest values was recorded with 'seed priming + formulation II @ 4g kg^{-1}' where in the plants recorded 90.07 seeds fruit^{-1}, 13.49 g of seed weight fruit^{-1} and a 100 seed weight of 16.24g. The increase in 100 seed weight is one of the important factors that had influenced that seed yield in the present study. The increase in 100 seed weight may be attributed to the enhancement of photosynthetic capacity of the plants as endorsed by the higher chlorophyll content recorded in this study (Table 4).

Thus concomitant to the vigourous plant growth recorded in 'seed priming + formulation II @ 4 g kg^{-1}' there was earlier initiation of male and female flowers, as well as higher number of female flowers plant^{-1}, resulted in higher number of fruits as well as higher number of seeds per fruit. The higher number of seeds as well as 100 seed weight has ultimately resulted in higher seed yield plot^{-1}.

The results of the study on field performance of ridge gourd, has established that seed priming and application of brassinosteroid through seed coating is very effective in improving the field emergence, crop growth, flowering , sex expression, fruit and yield characteristics and finally the fruit and seed yield. It is therefore concluded that seeds of ridge gourd may be subjected to seed priming and seed coating with brassinosteroid based seed coating formulation so as to enhance the crop growth and productivity.

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