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RESEARCH PAPER

Effect of microwaves on seed quality of sorghum

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Abstract: Due to ageing of seed over the time, seed losses its vigour and viability, which makes it unfit for sowing. So the study was conducted to check the efficacy of microwaves for seed treatment for seed quality enhancement. The objective of the study was to understand the effect of microwaves on physiological and biochemical attributes of seed quality of aged sorghum seeds. The sorghum seeds were subjected to ageing for 96 h of variety SPV-2217 to microwaves seed treatments of different intensities and time period *i.e.*30% intensity, 40% intensity and 50% intensity for 30 and 40 seconds which were compared with untreated control and seeds primed with $CaCl_2$ (2% for 8 h). Data was analyzed using completely randomized design and randomized block design with three replications.Considering the seed quality parameters the highest mean germination (82.33%), shoot length (16.8 cm), root length (16.2 cm), vigour index I (2717) and least electrical conductivity (0.773 dSm^{-1}) was noted in the seeds treated at 30% intensity for 40 seconds followed by the treatment 40% intensity for 30 seconds. The seedling dry weight (22.63 mg/seedling) and vigour index II (1848) was highest in the treatment 30% intensity for 30 seconds. These seed quality parameters were supported by biochemical parameters in which the treatment 40% intensity for 30 seconds showed highest traits for catalase (6.542 µM of H_2O_2 decomposed/min/mg protein), peroxidase (0.0484 µM min/mg protein of tetraguaiacol formed) and superoxide dismutase (16.69 units/mg protein), while alpha amylase was highest (0.611 µmol/min/mg protein) in 30% intensity for 30 seconds and proline (4.03 µM/g fresh weight) in 30% intensity for 40 seconds. The improvement of seed quality and biochemical parameters, ultimately resulted in better field parameters *i.e.* field emergence (81.33%), plant dry weight 30 days after sowing (20.32 g) and chlorophyll content (30.96 units) in the treatment 30% intensity for 30 seconds. While maximum plant height (71.5 cm) and number of leaves (5.0) in the treatment 40% intensity for 30 seconds. Decline was observed in all the parameters as the intensity and duration was increased beyond 40% intensity for 30 seconds. Hence, 30% intensity for 40 seconds was found to be the most effective treatment along with 40% intensity for 30 seconds.

Key words: Biochemical parameters, Field parameters, Microwaves, Seed treatment, Seed quality enhancement, Sorghum

Introduction

Sorghum (*Sorghum bicolor*-L-M Moench) is an important cereal crop, native to Africa with many cultivated forms. It ranks fifth among the world's cereals.Sorghum has been used as a staple food by millions of people, mainly in Africa and Asia, supplying about 70 per cent of the daily caloric intake and has an important role in food security of these populations. In India, the area is 4.24 mha with yield of 1128 kg per ha and production of 4.78 million tons. (Anon., 2021). Agricultural workers have long known the importance of quality seeds, which determines the value of the harvest and production quality. The quality of seed of any crop species is the crucial factor for its establishment and various experiments are being conducted to enhance the quality and determine the factors responsible for it. In India, it is observed that there is inefficient conversion of breeder seed to the certified seed (Singh and Singh, 2016). One of the major reason for this is failure of seed lots to pass the certification standards by marginal values.Seed deterioration and aging are considered as a force to reckon the depletion in food reserve, increased fat acidity, increased enzyme activity and membrane permeability. Due to ageing of seed over the time, seed losses its vigour and viability, which makes it unfit for sowing. Thus all such produced seed, failing certification, has to be consumed as grain which widens the gap further in demand and availability of certified seeds. Because of unavailability of certified seed, the seed replacement rate is also low. Physical methods of stimulation are considered as an innovative area of research and have emerged as a magic tool, which could improve the yield of crops. Microwaves are defined as electromagnetic radiations with a frequency ranging between 300 MHz to 300 GHz while the wavelength ranges from 1 mm to around 30 cm. The microwave radiation is commonly referred to as microwaves. The objective of the study is to understand the effect of microwaves on physiological and biochemical attributes of seed quality of aged sorghum seeds.

Materials and methods

The experiment was conducted at Department of Seed Science and Technology, University of Agricultural Sciences, Dharwad, Karnataka. Seeds of SPV-2217, a *rabi* sorghum variety were used for the experiment. Freshly obtained breeders' seeds had high germination percentage (98 per cent), so they were subjected for accelerated ageing treatment at 45±1^{0}C temperature and 95±1% relative humidity for 96 hours *i.e.* 4 days to reduce its germination per cent to 78 and also the vigour. The aged seeds were used as control and also were subjected to further treatments by physical radiations.

Microwaves seed treatments of different intensities and time periods *i.e.*T1: 30% intensity for 30 seconds, T2: 30%

Table 1. Effect of microwaves on seed quality parameters of sorghum

Treatments (Intensity/duration)	Germination (%)	Shoot length (cm)	Root length (cm)	Vigour index I	Seedling dry weight (mg /10 seedlings)	Vigour index II (dSm^{-1})	Electrical conductivity
T_1	81.67*(64.62)**	14.4	13.9	2311	226.3	1848	0.831
T_2	82.33(65.12)	16.8	16.2	2717	221.3	1822	0.773
T_3	80.67(63.89)	16.6	16.0	2630	218.0	1759	0.792
T_4	80.00(63.41)	14.4	13.4	2264	211.7	1693	0.879
T_5	78.67(62.47)	11.7	11.0	1786	198.3	1560	0.921
T_6	74.00(59.33)	11.1	10.5	1598	187.3	1386	0.949
T_7	78.00(62.01)	14.0	13.5	2145	195.0	1521	1.007
T_8	81.00(64.14)	14.7	14.1	2333	209.0	1693	0.888
Mean	79.56(63.14)	14.2	13.6	2221	210.5	1678	0.858
S. Em±	0.41	0.86	0.86	57	1.78	14.11	0.0095
C. D. at 1%	1.67	3.25	3.24	237	7.33	58.3	0.0391

* Original values **Values with parentheses are arc sined.

intensity for 40 seconds, T3: 40% intensity for 30 seconds, T4: 40% intensity for 40 seconds, T5: 50% intensity for 30 seconds and T6: 50% intensity for 40 seconds were given to the seed using a IFB microwave with the power 0.9 kW and frequency of 2.45 GHz and were compared with T7: untreated control and T8: seeds primed with $CaCl_2$ (2% for 8 hours). Different seed quality parameters *i.e.* germination per cent, shoot length (cm), root length (cm), seedling dry weight (mg / 10 seedlings), seedling vigour indices I and II, biochemical parameters *i.e.* α – amylase (µmol/min/mg protein), catalase (µ moles of H_2O_2 decomposed /min/mg protein), peroxidase (µ moles min/mg protein of tetra-guaiacol formed), superoxide dismutase (units/mg protein), proline content (µ moles/g fresh weight) and early field parameters *i.e.* field emergence percent, plant height at 30 DAS, number of leaves at 30 DAS, plant dry weight at 30 DAS (g), chlorophyll content (SPAD readings). The data was analyzed statistically as described by Gomez and Gomez (1984). Standard error of difference was calculated for each treatment effect and critical difference (CD) values were calculated at one per cent ($P \leq 0.01$) for probability level where 'F' test was found significant for laboratory experiments. For field parameters, critical difference (CD) values were calculated at five per cent ($P \leq 0.05$) for probability level where 'F' test was found significant.

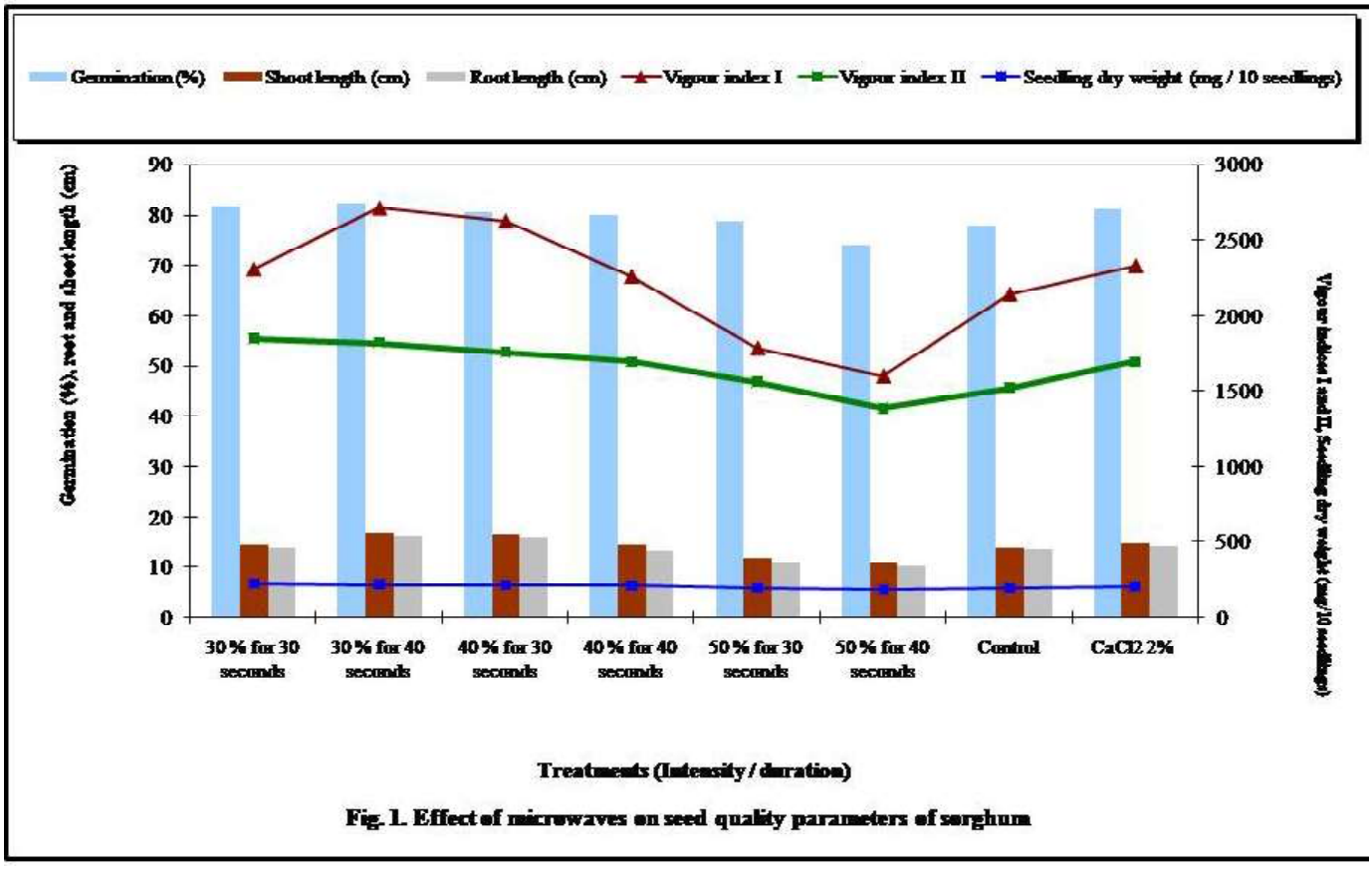

Fig. 1. Effect of microwaves on seed quality parameters of sorghum

Table 2. Effect of microwaves on biochemical parameters of sorghum

Treatments (Intensity/duration)	á – amylase (µmol/min/mg protein)	Catalase (µM of H_2O_2 decomposed /min/mg protein)	Peroxidase (µM of tetraguaiacol formed/min/mg protein)	Superoxide dismutase (Units/mg protein)	Proline (µM/gfresh weight)
T_1	0.611	5.346	0.0328	15.07	2.81
T_2	0.596	4.059	0.0339	16.04	4.03
T_3	0.601	6.542	0.0484	16.69	3.61
T_4	0.552	4.063	0.0386	15.83	2.87
T_5	0.566	3.802	0.0216	12.42	1.79
T_6	0.583	2.907	0.0229	11.99	1.40
T_7	0.567	4.158	0.0239	16.13	1.71
T_8	0.580	4.228	0.0375	16.73	5.90
Mean	0.585	4.453	0.0330	14.67	2.75
S.Em±	0.011	0.518	0.0026	0.32	0.29
C.D. at 1 %	0.044	2.138	0.0108	1.33	1.20

Results and discussion

Effect of microwaves on seed quality parameters

The results on seed quality parameters as influenced by microwave radiations are presented in Table 1 (Fig. 1). It was observed that in most of the parameters, the values initially increased with increase in intensity and time period, but has shown the further decline.The highest mean germination (82.33%), shoot length (16.8 cm), root length (16.2 cm), vigour index I (2717) and least electrical conductivity (0.773 dSm^{-1}) was noted in the treatment 30% intensity for 40 seconds followed by the treatment 40% intensity for 30 seconds showing the second highest increase as good as the best. While seedling dry weight (226.3 mg/ten seedlings) and vigour index II (1848) was highest in the treatment 30% intensity for 30 seconds.The accelerated germination and improved germinating energy of certain doses in current study could be due to the eventual disturbance of the seed coat under the influence of the microwave treatment, which facilitated water penetration into the seeds and the start of the initial development stages occurred. (Luliana *et al*., 2013). The effect of microwave on various growth parameters *e.g*. germination rate and shoot growth rate showed that microwave radio frequencies possibly retard germination at higher powers due to the consequence on spindle growth being uncertain (Monteiro *et al*., 2008). The rising trend of electrolyte leakage may be ascribed to the acceleration of material exchange inside and outside the cells induced by the microwave irradiation due to the loss of enzyme activity within the cell membrane. Hence, the metal ions were excluded through the membrane, leading to a significant increase of electrolyte leakage (Woo *et al*., 2000).

Effect of microwaves on biochemical parameters

The results on biochemical parameters as influenced by microwaves radiations are presented in Table 2 (Fig 2). The biochemical parameters followed similar trend as the one observed in seed quality parameters. The treatment 40% intensity for 30 seconds showed highest traits for catalase (6.542 µM of H_2O_2 decomposed/min/mg protein), peroxidase (0.0484 µM of tetraguaiacol formed/min/mg protein) and superoxide dismutase (16.69 units/mg protein), while α- amylase was highest (0.611 µmol/min/mg protein) in 30% intensity for

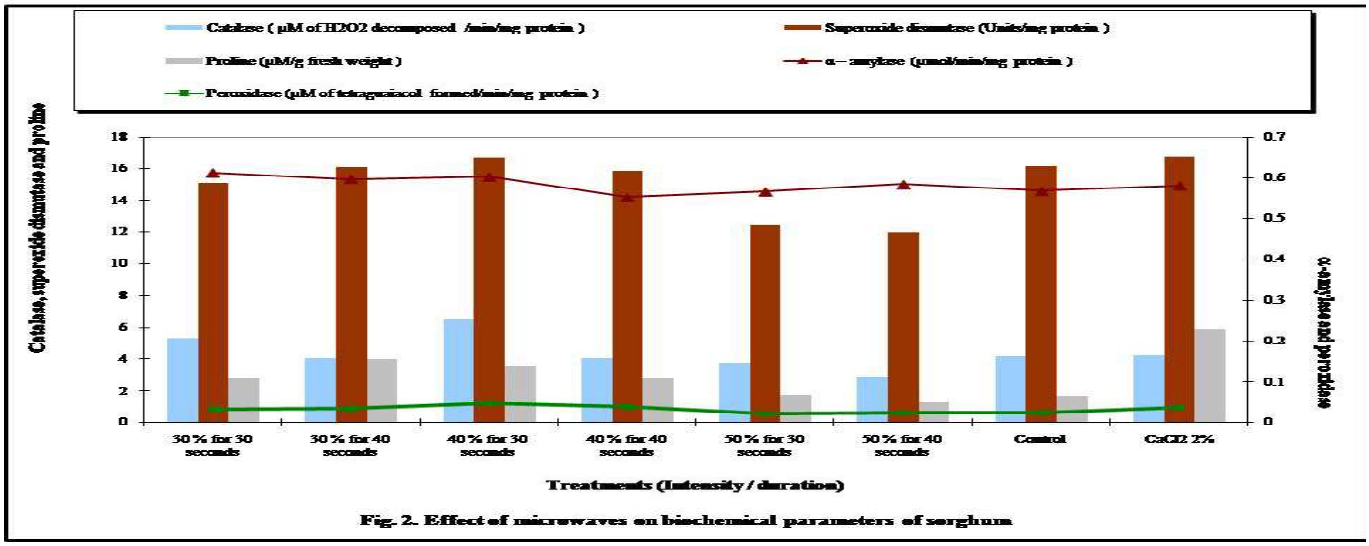

Fig. 2. Effect of microwaves on biochemical parameters of sorghum

Table 3. Effect of microwaves on early field parameters of sorghum

Treatments (Intensity/duration)	Field emergence %	Plant height (cm)at 30 DAS	Number of leaves at 30 DAS	Plant dry weight (g)at 30 DAS	Chlorophyll content(SPAD value)
T_1	80.33*(63.65)**	64.1	3.8	18.50	29.18
T_2	81.33(64.38)	69.0	4.6	20.32	30.96
T_3	78.33(62.24)	71.5	5.0	18.70	30.48
T_4	77.00(61.32)	61.1	3.8	16.10	29.30
T_5	72.67(58.46)	56.1	3.6	13.68	25.16
T_6	70.00(56.77)	49.3	3.4	13.00	25.54
T_7	73.67(59.10)	56.1	3.6	13.18	26.20
T_8	77.00(61.32)	59.9	3.8	14.72	29.36
Mean	76.61(61.14)	61.9	4.0	16.72	28.44
S.Em±	0.62	0.66	0.36	0.60	0.55
C.D. at 5 %	1.34	1.36	0.75	1.23	1.13

* Original values **Values with parentheses are arcsined.

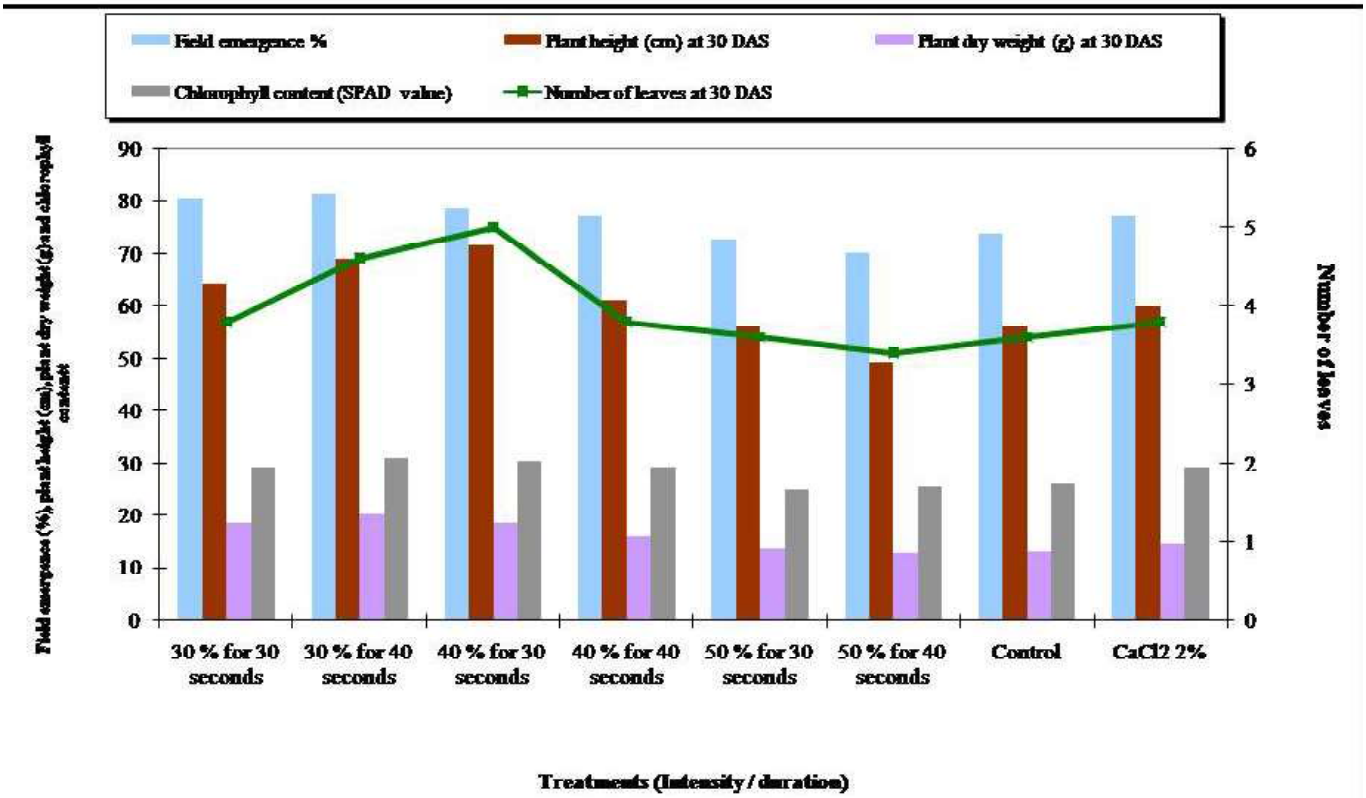

Fig. 3. Effect of microwaves on early field parameters of sorghum

30 seconds and proline (4.03 µM/g fresh weight) in 30% intensity for 40 seconds.The initial increase might be due to some stimulation at cell organelles level. When bigger energy is absorbed by organelles at higher output power and longer exposure time of microwaves, they could destroy cell functions causing reduction in enzymatic activity and stimulation effect could not be achieved (Aladjadjiyan, 2010).

Effect of microwaves on early field parameters

The results on early field parameters as influenced by microwaves radiations are presented in Table 3 (Fig 3).Better seed quality and enhanced enzymatic system clearly showed their effect leading to better field parameters. *i.e.* field emergence (81.33%), plant dry weight 30 days after sowing (20.32 g) and chlorophyll content (30.96 units) in the treatment 30% intensity for 30 seconds. While maximum plant height (71.5 cm) and number of leaves (5.0) in the treatment 40% intensity for 30 seconds. Decline was observed in all the parameters as the intensity and duration was increased beyond 40% intensity for 30 seconds due to damage to seeds with maximum reduction observed in 50% intensity for 40 seconds.

Conclusion

The microwaves radiation treatment 30% intensity for 40 seconds was found to be the most effective treatment along with 40% intensity for 30 seconds and can be effectively used

to improve the quality of low vigour seed lots and to save the seed lots which may fail in seed germination tests by upto five per cent. This method can be used in the organic production of seeds. Priming of the seeds uses hydration technique, which causes soaking injury to many seeds. In such cases this method can be effectively used for quality enhancement.

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