



E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; SP1: 1593-1597

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Effect of microwave intensityon plant growth, seed yield, quality and biochemical parameters of rabi sorghum [*Sorghum bicolor* (L.) Moench] under rainfed conditions

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Abstract

In the present investigation, the field experiment and laboratory experiment were laid out in Factorial Randomized Block Design and Factorial Completely Randomized Design, respectively with three replications involving two varieties viz., (V₁) Phule Vasudha and Phule Suchitra (V₂). The seeds were treated with the combination of three microwave intensities (I₁ - 20%, I₂ - 30% and I₃ - 40%) and durations of exposure (D₁ - 30 sec., D₂ - 40 sec. and D₃ - 50 sec.) The microwave intensity stimulation treatments were applied before sowing of seeds. The observations were recorded on growth, seed yield and seed quality parameters. The seeds treated with microwave intensities and durations of exposure have significant effect on plant growth, seed yield, quality and biochemical parameters of *rabi* sorghum under rainfed condition. Among the varieties, the variety Phule Vasudha revealed significant results than variety Phule Suchitra. The seeds treated with the microwave intensity of 30 % and duration of exposure for 40 sec. (I₂D₂) exhibited higher field emergence percentage, plant height, panicle length, panicle girth, number of seeds per panicle, 1000 seed weight, seed yield per plant, seed yield per plot, seed yield per hectare, and harvest index and also showed better seed quality and biochemical parameters viz., germination percentage, root length, shoot length, vigour index-I, vigourindex-II, enzymatic activities like proline content, glycine betaine activity, peroxidase activity, superoxide dismutase activity, Catalase activity and α -amylase activity. Whereas, the lower values were observed for days to field emergence, days to 50% flowering, and electrical conductivity of seed leachates followed by interaction of microwave intensity 30% for duration of exposure 30 seconds (I₂D₁) as compared to other interactions. Thus, it is concluded that the seeds of variety Phule Vasudha applied with 30% microwave intensity for 40 seconds duration of exposure exhibited superior field emergence percentage, successful establishment of seedling and also to get higher seed yield and better seed quality of *rabi* sorghum under rainfed condition.

Keywords: microwave intensityon, seed yield, *Sorghum bicolor* (L.) Moench

Introduction

Sorghum is the fifth most important cereal crop next only to rice, wheat, maize and barley. It is the staple food of poor and the most food insecure people, living mainly in the semi-arid and tropics. There has been drastic reduction in sorghum area especially in the rainy season, but the area under post-rainy sorghum has remained stable. Post-rainy season-adapted sorghums are characterized by response to shorter day-length (photoperiod sensitivity), flowering and maturity (more or the less same time), irrespective of temperature fluctuations and sowing dates (thermo-insensitivity within the post-rainy season varieties). They are tolerant to terminal moisture stress and resistant to stalk rot/charcoal rot. They usually produce high biomass and have high lustrous seed with semi-corneous endosperm.

The low yield of sorghum affected by various biotic and abiotic stresses. Moisture stress is one of the important drought factors. Nearly 70% sorghum area depends on rains and rains are not assured in most of the sorghum growing areas. These conditions leads to the problem of drought. As such the crop productivity in these areas is low. Moisture stress causes depletion in soil and water deficit with a decrease of water potential in plant tissues. It restricts the expression of full genetic potential of the plant. Moisture stress is a major constraint limiting sorghum crop growth and reducing its productivity. Many researches on the soil water relationship in sorghum and other crops have indicated that growth and yield are directly controlled by plant water deficit. This may be influenced by moisture.

Physical methods for seed treatment such as electric and magnetic field of different frequencies significantly improve the seed germination and seed yield in rainfed conditions. In order to improve quality of seed in respect of crop stand, many workers studied the effect of

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electrical stimulus on seed viability, vigour, seed germination and seedling growth and found positive results. 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. Seed is an extremely complex system and its state cannot always be controlled due to changing of seed vitality indices viz., germinating energy, germination and uniformity of germination. Physical methods of seed treatment may initiate physiological and biochemical changes which reflect on the plant growth and development processes and ultimately improve the yield and quality of produce and also help to elucidate the mechanisms of energy exchange in molecules and thus stimulation of plant development. It is a kind of energy treatment that stimulates the enzymes and other biochemical reactions that helps in early germination. The stimulation is possible at lower levels of treatment intensity/energy.

Material and Methods

The experiment consists of two *rabisorghum* varieties viz., V₁- PhuleVasudha and V₂- PhuleSuchitra treated with different biophysical stimulation treatments of microwave intensities i.e. I₁- 20%, I₂- 30% and I₃- 40% for different durations of exposure D₁- 30 sec., D₂- 40 sec and D₃- 50 sec., respectively. The recommended culture practices were followed to raise the crop. The observations of field characters like days to field emergence, field emergence percentage, days to 50% flowering, plant height, panicle length, panicle girth, number of seeds per panicle, 1000 seed weight, seed yield per plant, seed yield per plot, seed yield per hectare and harvest index as well as the seed quality and biochemical parameters like germination percentage, root length, shoot length, seedling dry weight, vigour index-I &II and electrical conductivity of seed lechates, biochemical parameters like proline content, glycine betaine activity, peroxidase activity, superoxide dismutase activity, Catalase activity and α -amylase activity were recorded. The data obtained from all the parameters in field was analyzed by using Factorial Randomized Block Design (FRBD) and in laboratory by using Factorial Completely Randomized Design (FCRD) as per Panse&Sukhatme (1985).

Results and Discussion

In the present investigation, field experiment resulted as the interaction effect of varieties, microwave intensities and duration of exposures, the seeds of variety PhuleVasudha (V₁) treated with 30% microwave intensity for 40 second duration of exposure (V₁I₂D₂) reveled higher field emergence percentage (77.63%), panicle length (22.75 cm), panicle girth (17.17 cm), number of seeds per panicle (2249.43), 1000 seed weight (32.28 g), seed yield per plant (53.30 g), seed yield per plot (1.94 kg), seed yield per hectare (2270.13 kg) and harvest index (29.32%) as compared to other interactions of varieties, microwave intensities and durations of exposure. While, the interaction effect of varieties, microwave intensities and durations of exposure showed non-significant influence on days to field emergence, days to 50% flowering and plant height.

The microwave application might stimulates the enzymatic activities and results in group of gene action responsible for early field emergence and enhanced field emergence percentage. Seeds treated with optimum microwave intensity and exposure duration enhances the metabolic activities, accelerates the cellular multiplication and enzymatic activities

resulted in higher field emergence, different electrogenic treatments might leads to cell enlargement and increase in normal cell division. Comparing the biophysical stimulation treatments, treatment of 30% microwave intensity for duration of 40 seconds reported better results for seed yield and yield contributing characters. The performance of yield contributing parameters depends on growth and phenological character of crop and contributes in final yield.

The study of different seed quality parameters resulted as the interaction effect of varieties, microwave intensities and duration of exposures, variety Phule Vasudha treated with 30% microwave intensity for 40 second duration of exposure (V₁I₂D₂) reveled higher germination percentage (87.92%), root length (23.71 cm), shoot length (24.69 cm), seedling dry weight (1.437 mg), vigour index-I (4247.43) and vigour index-II (124.67) lower electrical conductivity of seed leachates (1.25 dSm⁻¹) as compared to other interactions of varieties, microwave intensities and duration of exposures.

Experiment also includes the study of different biochemical parameters which resulted as the interaction effect of varieties, microwave intensities and duration of exposures, variety Phule Vasudha treated with 30% microwave intensity for 40 second duration of exposure V₁I₂D₂ reveled higher proline content (3.53 μ mole gram⁻¹fr. wt.), glycine betaine (5.55 μ moles g⁻¹fr. wt.), peroxidase activity (61.28nanomoles of tetra-guaiacol formed mg⁻¹ protein min⁻¹), superoxide dismutase activity (32.87 unit mg per protein), Catalase activity (6.10 μ moles H₂O₂ decomposed mg⁻¹ protein min⁻¹) and α -amylase activity (0.264 μ g of maltose mg⁻¹protein) as compared to other interactions of varieties, microwave intensities and duration of exposures.

Application of microwave intensity stimulation treatments causes physiological changes in seeds that resulting in enzymatic activation, which increased the biological capacities of seed. It has been believed that biological process including free radicals; excite the activity of proteins and enzymes which increased seed power. That affects seed germination, field emergence, growth rate and seed vigour. The microwave exposure of seeds may result in breaking of hydrogen bonding in ultra-structural elements of cell. This structural alteration may increase enzyme activity depending on the strength of microwave and durations of exposure. This might have resulted increased in seed germination; seedling length and seedling dry weight which also enhanced the seedling vigour, might have resulted better germination of sorghum than untreated control.

Microwave intensities application enhances the proline content and glycine betaine activity, in which protein salvation and preserves the quaternary structure of complex proteins, which maintains membrane integrity under dehydration stress and reduces oxidation of lipid membranes or photoinhibition. Furthermore, it also contributes to stabilizing sub-cellular structures, scavenging free radicals, and buffering cellular redox potential under stress conditions. Metabolically active tissues of plant cell contains free radicals, highest contain of free radicals was observed in embryo axis immediately after emergence of radicals. Microwave intensity increases the average radical concentration, prolonging their lifetime and enhancing the probability of radical reaction with cellular components. This consideration also applied to enzymatic system that entails radical pair formation and recombination.

Table 1: Interaction effect of varieties, electric field intensities, duration of exposure on seed yield and yield contributing characters

V X I X D Interaction	Days to field emergence	Field emergence (%)	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	Panicle girth (cm)	No. of seeds per panicle	1000 seed weight (gm)	Seed yield per plant (gm)	Seed yield per plot (kg)	Seed yield per hectare (kg)	Harvest index (%)
V ₁ I ₁ D ₁ - (PhuleVasudha + 20% + 30 sec.)	8.16	73.83	76.16	254.58	18.31	15.36	2055.46	28.91	43.41	1.67	2079.23	22.77
V ₁ I ₁ D ₂ - (PhuleVasudha + 20% + 40 sec.)	8.16	74.25	76.16	246.83	20.84	15.66	2032.28	28.35	45.02	1.74	2136.58	22.01
V ₁ I ₁ D ₃ - (PhuleVasudha + 20% + 50 sec.)	7.33	75.25	75.33	219.58	20.35	16.07	2135.57	29.63	51.07	1.84	2234.36	26.97
V ₁ I ₂ D ₁ - (PhuleVasudha + 30% + 30 sec.)	7.00	76.00	75.00	254.75	23.51	16.61	2160.00	30.16	51.74	1.86	2246.73	27.72
V ₁ I ₂ D ₂ - (PhuleVasudha + 30% + 40 sec.)	6.50	77.63	74.50	256.28	22.75	17.17	2249.43	32.28	53.30	1.94	2270.13	29.32
V ₁ I ₂ D ₃ - (PhuleVasudha + 30% + 50 sec.)	7.83	73.18	75.83	253.20	20.72	15.74	2084.40	28.61	47.65	1.73	2121.31	25.01
V ₁ I ₃ D ₁ - (PhuleVasudha + 40% + 30 sec.)	8.00	72.00	76.00	246.83	19.25	15.48	2072.44	29.44	46.48	1.78	2181.47	24.18
V ₁ I ₃ D ₂ - (PhuleVasudha + 40% + 40 sec.)	8.33	73.16	76.33	248.73	17.99	16.20	2065.82	28.76	45.58	1.76	2200.73	23.82
V ₁ I ₃ D ₃ - (PhuleVasudha + 40% + 50 sec.)	8.00	74.50	75.50	253.40	18.41	15.27	2117.97	28.92	45.85	1.58	2045.07	23.54
V ₂ I ₁ D ₁ - (PhuleSuchitra + 20% + 30 sec.)	8.00	74.41	76.00	248.11	20.09	15.64	2016.24	29.48	43.59	1.60	1990.08	22.75
V ₂ I ₁ D ₂ - (PhuleSuchitra + 20% + 40 sec.)	8.16	74.89	76.16	248.01	20.10	14.76	2015.61	29.27	47.35	1.63	1976.92	24.57
V ₂ I ₁ D ₃ - (PhuleSuchitra + 20% + 50 sec.)	7.66	75.58	75.66	249.28	20.74	16.20	2157.81	31.12	49.15	1.74	2109.38	25.91
V ₂ I ₂ D ₁ - (PhuleSuchitra + 30% + 30 sec.)	7.16	76.66	75.16	255.72	21.58	16.38	2173.95	31.31	51.38	1.77	2135.26	26.96
V ₂ I ₂ D ₂ - (PhuleSuchitra + 30% + 40 sec.)	6.83	75.92	74.83	260.01	22.58	16.42	2243.08	31.72	52.61	1.87	2247.62	28.45
V ₂ I ₂ D ₃ - (PhuleSuchitra + 30% + 50 sec.)	8.00	74.00	76.00	249.13	19.23	15.70	2039.52	30.50	47.83	1.64	2057.14	24.78
V ₂ I ₃ D ₁ - (PhuleSuchitra + 40% + 30 sec.)	8.16	73.08	76.16	249.45	19.24	15.35	2066.35	30.46	45.43	1.57	2026.23	23.29
V ₂ I ₃ D ₂ - (PhuleSuchitra + 40% + 40 sec.)	8.33	72.95	76.33	257.41	18.98	14.69	2110.29	28.95	44.92	1.59	1989.16	22.76
V ₂ I ₃ D ₃ - (PhuleSuchitra + 40% + 50 sec.)	8.50	72.30	76.50	257.56	17.61	13.72	1885.71	27.40	41.04	1.47	1923.70	21.06
MEAN	7.87	73.87	75.87	247.90	20.05	15.47	2096.89	29.72	47.31	1.71	2115.48	24.56
SEm (\pm)	0.83	1.06	1.30	5.942	0.92	0.84	39.17	1.14	1.47	0.07	59.36	0.55
CD @ 5%	NS	3.18	NS	NS	2.74	2.41	116.52	3.42	4.26	0.21	178.70	2.24

Table 2: Interaction effect of varieties, electric field intensities, duration of exposure on seed quality characters

V X I X D Interaction	Germination (%)	Root length (cm)	Shoot length (cm)	Seedling dry weight	Vigour index-I	Vigour index-II	EC (dsm ⁻¹)	Proline content	Glycine betaine activity	Peroxidase activity	SOD	Catalase activity	α -Amylase activity
V ₁ I ₁ D ₁ - (PhuleVasudha + 20% + 30 sec.)	83.83	21.81	21.81	1.254	3714.74	105.48	1.890	2.85	3.73	48.37	25.05	4.04	0.197
V ₁ I ₁ D ₂ - (PhuleVasudha + 20% + 40 sec.)	84.25	20.72	20.72	1.308	3624.18	109.56	2.060	2.56	3.79	49.45	27.39	3.96	0.194
V ₁ I ₁ D ₃ - (PhuleVasudha + 20% + 50 sec.)	85.25	22.38	22.38	1.359	3842.49	117.12	1.515	3.07	4.57	53.42	29.89	5.06	0.243
V ₁ I ₂ D ₁ - (PhuleVasudha + 30% + 30 sec.)	86.00	22.92	22.92	1.313	3969.64	119.27	1.500	3.19	4.94	54.41	30.67	5.38	0.247
V ₁ I ₂ D ₂ - (PhuleVasudha + 30% + 40 sec.)	87.92	23.71	23.71	1.437	4247.43	124.67	1.250	3.53	5.55	61.28	32.87	6.10	0.264
V ₁ I ₂ D ₃ - (PhuleVasudha + 30% + 50 sec.)	82.08	21.65	21.65	1.345	3675.45	111.55	1.655	2.91	3.14	48.13	26.60	4.18	0.214
V ₁ I ₃ D ₁ - (PhuleVasudha + 40% + 30 sec.)	82.00	21.67	21.67	1.351	3593.81	110.93	1.845	2.94	3.78	48.56	25.02	4.37	0.184
V ₁ I ₃ D ₂ - (PhuleVasudha + 40% + 40 sec.)	83.16	22.01	22.01	1.339	3688.42	109.84	1.870	2.44	3.57	43.28	25.42	4.58	0.188
V ₁ I ₃ D ₃ - (PhuleVasudha + 40% + 50 sec.)	84.50	21.41	21.41	1.216	3649.51	107.83	1.768	2.42	4.01	46.11	27.46	4.69	0.191
V ₂ I ₁ D ₁ - (PhuleSuchitra + 20% + 30 sec.)	84.41	21.73	21.73	1.283	3821.87	108.66	2.043	2.28	4.17	51.54	22.22	3.67	0.217
V ₂ I ₁ D ₂ - (PhuleSuchitra + 20% + 40 sec.)	84.84	19.69	19.69	1.305	3614.98	109.82	1.758	2.62	3.87	55.16	24.45	3.65	0.158
V ₂ I ₁ D ₃ - (PhuleSuchitra + 20% + 50 sec.)	85.58	22.53	22.53	1.376	3959.33	116.78	1.590	2.94	4.56	56.41	28.34	5.12	0.239
V ₂ I ₂ D ₁ - (PhuleSuchitra + 30% + 30 sec.)	86.66	22.87	22.87	1.383	4049.36	118.45	1.505	3.08	4.90	57.22	28.97	5.39	0.242
V ₂ I ₂ D ₂ - (PhuleSuchitra + 30% + 40 sec.)	87.22	23.36	23.36	1.419	4192.66	121.20	1.437	3.32	5.38	60.23	31.72	5.91	0.251
V ₂ I ₂ D ₃ - (PhuleSuchitra + 30% + 50 sec.)	84.00	20.77	20.77	1.323	3665.82	111.27	1.690	2.83	4.16	53.01	25.14	4.62	0.226
V ₂ I ₃ D ₁ - (PhuleSuchitra + 40% + 30 sec.)	83.08	22.04	22.04	1.302	3797.12	109.56	1.895	2.43	3.91	54.43	24.84	4.15	0.227
V ₂ I ₃ D ₂ - (PhuleSuchitra + 40% + 40 sec.)	82.25	22.30	22.30	1.303	3772.33	108.15	2.050	2.54	4.14	51.09	23.27	4.63	0.229
V ₂ I ₃ D ₃ - (PhuleSuchitra + 40% + 50 sec.)	81.33	19.19	19.19	1.144	3538.10	98.27	2.510	2.11	3.10	40.85	17.83	2.60	0.166
MEAN	83.72	21.72	21.72	1.313	3748.36	110.29	1.825	2.73	4.089	51.13	25.85	4.50	0.208
SEm (\pm)	0.55	0.28	0.28	0.02	54.02	8.68	0.04	0.26	0.22	2.39	1.78	0.38	0.012
CD @ 1%	2.24	1.13	1.13	0.08	216.08	32.03	0.15	1.06	0.89	9.58	7.12	1.52	0.048

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