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## Seed Physiological Quality of Three *Capsicum* Species as Affected by Seed Density and Hydropriming Treatment Durations

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**Abstract:** Seeds uniformity and seedling establishment are major problem in pepper production in developing countries and have great impact on production quality and performance. Seed enhancement technology like hydropriming can be done to address this gap. A study was initiated to determine the physiological quality of three *Capsicum* species (*Capsicum annuum*, *Capsicum frutescens* and *Capsicum chinense*) in relation to seed density and hydropriming treatment durations. In the first experiment, fresh ungraded seeds were subjected to different hours of hydropriming durations with second experiment light and heavy density seed lots were subjected to the same hydropriming durations. Seedling emergence, energy of emergence, seedling vigour index and emergence rate were evaluated in the experiments. The result revealed that among the ungraded, light and heavy density seed lots, *Capsicum chinense* had superior seedling emergence, energy of emergence, seedling vigour index and emergence index. Hydropriming for 0 to 12 h resulted in lower days to emergence. Hydropriming of light density seeds gave high seedling emergence in the three *Capsicum* species compared to hydropriming of heavy density seeds. An increase in hydropriming durations of the light density seeds resulted in an increase in the seedling emergence, energy of emergence, seedling vigour and emergence index. Positive and significant relationships were obtained between seedling emergence or energy of emergence and seedling vigour index in each of the three *Capsicum* species over the hydropriming durations. Therefore, the study suggests the use of hydropriming as a simple and cost-effective strategy in pepper production especially in developing countries.

**Key words:** Emergence, *Capsicum* spp., seed vigour, seed quality, seed weight

### INTRODUCTION

*Capsicum* belongs to the kingdom plantae, order solanales, family Solanaceae and genus *Capsicum*. The genus *Capsicum* is a member of the solanaceae family that includes tomato, potato and petunia. It was reported that *Capsicum* has been part of the human diet since 7500 BC and has been in existence since the beginning of civilization in the Western Hemisphere (Bosland, 1994).

Hydropriming has been described as a very important seed treatment technique which results in rapid germination and uniform stand establishment in various crops (Adebisi *et al.*, 2011; Abale and Modi, 2009). Germination conditions, seed and seedling growth strength have been reported to be improved through the process of hydropriming (Ellis, 1989; Drew *et al.*, 1997; Srinivasan *et al.*, 1999). A significant difference in hydropriming durations on seed germination, stem weight and plant height was reported by Moosavi *et al.* (2012) in soybean and soaking in water for 8 h was desirable and

recommended. Abale and Modi (2009) also observed that seed priming, cultivar and interaction were highly significant at the 2, 4 and 8 day germination and found hydropriming to be unnecessary in dry bean seed (*Phaseolus vulgaris*). Kenaf seeds were reported to experience improved germination and vigour after hydropriming by Daniel *et al.* (2012).

Quality of seed of pepper species is an important factor in pepper production especially during nursery establishment (Ladipo, 2009; Omotosho, 2009). In developing countries, seed soaking seems to be one of the ways that resource poor farmers can prepare their seeds for improvement of emergence in some crop species from season to season. Production of pepper has been reported to experience low emergence and seedling vigour (Adetiloye, 2005). Seed viability and seedling vigour are affected by seed moisture level, soaking hours, drying temperature, seed weight, genetic constitution and length of storage (Adetiloye, 2005; Adebisi and Oyekale, 2005). From available literatures scanty information is available

on the effectiveness of seed density and hydropriming on the improvement of emergence and vigour of three main *Capsicum* species in Nigeria. The result of study would therefore help to determine if hydropriming of heavy and light density seeds of *Capsicum species* over different hours could improve rate of emergence and seedling vigour in pepper *Capsicum* species. The objectives of the study were to determine the influence of seed density and hydropriming in water on emergence and seedling vigour characters in three *Capsicum* species (*Capsicum annuum*, *Capsicum frutescens* and *Capsicum chinense*) and to determine the relationships among seed emergence characters after hydropriming treatment durations of ungraded heavy and light graded density seeds.

## MATERIALS AND METHODS

**Experimental site:** The experiment was conducted in the screen house of the Federal University of Agriculture Abeokuta, Ogun State in two trials. The first trial was conducted between April and May 2009, while the second trial was between August and September, 2009.

Mature ripe fruits of three *Capsicum* species (*Capsicum annuum*, *Capsicum frutescens* and *Capsicum chinense*) obtained from the National Institute of Horticultural Research (NIHORT), Ibadan Nigeria were used for the study.

**Experiment 1:** Hundred seeds ungraded extracted from matured ripe fruits of three species in four replicates were soaked in water for 0, 6, 12 and 18 h and then sown in rectangular plastic buckets with height of 5.1, 14.7 cm in length and 9.3 cm in breadth in the screen house. The buckets used for the experiment were filled with soil and perforated at the base to facilitate easy drainage and aeration. The experiment was arranged in a completely randomized design with two factors (Species and soaking duration) with a total of 96 treatments (3 species × 4 soaking hours × 4 replicates × 2 trials).

**Experiment 2:** Hundred seeds extracted from mature ripe fruits of the three *species* in four replicates were separated by sedimentation into heavy and light density seeds. Seeds that floated were labeled light seeds and those that sedimented were labeled heavy seeds. Hundred seeds from each of the two lots in four replicates were sown in plastic buckets (as in experiment 1) filled with top soil in screen house. The two seed lots were soaked in water for 0, 6, 12 and 18 h before sowing. The experiment was arranged in a completely randomized design with three factors (Species, trial and soaking durations) for each of

heavy and light density seeds. It had a total of 96 treatments (3 species × 4 soaking × 2 trials × 4 replicates).

**Seed quality assessment:** The seeds for the two experiments were tested for five physiological quality traits according to methods and procedures outlined by Fakorede and Ojo (1981) and Adebisi and Oyekale (2005):

$$\text{Emergence percentage} = \frac{\text{Seedling emergence 14 Days after sowing (DAS)}}{\text{No. of seeds sown}} \times 100$$

$$\text{Energy of emergence} = \frac{\text{Emergence 10 DAS}}{\text{No. of seeds sown}} \times 100$$

**Seedling vigour index:** Seedling vigour levels of seeds of each species was calculated by multiplying percent normal germination by the average of plumule length for each species after 14 days of germination and divided by 100 (Kim *et al.*, 1994; Adebisi, 2004):

$$\text{Emergence rate index} = \frac{\text{Emergence index}}{\text{Emergence percentage}}$$

$$\text{Emergence index} = \frac{\text{Plants emergence 10 (DAS)}}{\text{Plants emergence 14 (DAS)}}$$

**Data analysis:** The data collected from both experiments were subjected to statistical analyses thus; Analysis of Variance (ANOVA) to determine significant effect of the factors examined. Significance of treatment means was determined using Tukey Honestly Significant Difference (Tukey HSD) at 5% level of probability. Correction analysis among seed quality traits was determined across the trials and all the soaking hours for ungraded seeds, heavy and light graded seeds.

## RESULTS

**Hydropriming and seed quality of ungraded seeds of *Capsicum* species:** Table 1 shows the effect of water soaking treatment duration on seedling emergence and energy of emergence of ungraded seeds over three *Capsicum* species. In terms of seedling emergence, *Capsicum chinense* had the highest (77%) which was not significant different from the value obtained with *Capsicum frutescens* but higher than the value with *Capsicum annuum* (67%) at 0 h soaking time. At 6, 12 and 18 h soaking time, *Capsicum chinense* consistently recorded the highest seedling emergence compared to the other two species. *Capsicum annuum* had the lowest seedling emergence at 0, 6 and 18 h soaking time. On the overall mean of species, *Capsicum chinense* had the highest seedling emergence (69%) followed by

Table 1: Effect of hydropriming treatment duration on seedling emergence and energy of emergence of three pepper species over two trials

Species	Soaking time (hours)				Mean of species
	0	6	12	18	
<b>Seedling emergence</b>					
<i>Capsicum annuum</i>	67	58	60	27	53
<i>Capsicum frutescens</i>	71	66	59	43	60
<i>Capsicum chinense</i>	77	72	66	59	69
Mean of soaking time	71	65	61	43	
Standard Error	4.12				
Tukey HSD (0.05)	6.84				
<b>Energy of emergence</b>					
<i>Capsicum annuum</i>	55	38	46	16	39
<i>Capsicum frutescens</i>	53	60	47	33	48
<i>Capsicum chinense</i>	67	65	61	56	62
Mean of soaking time	58	54	51	35	
Standard Error	4.21				
Tukey HSD (0.05)	6.84				

Table 2: Effect of hydropriming treatment duration on seedling vigour, emergence index and emergence rate index of three pepper species over two trials

Species	Soaking time (hours)				Mean of species
	0	6	12	18	
<b>Seedling vigour index</b>					
<i>Capsicum annuum</i>	1.40	1.12	1.14	0.62	1.07
<i>Capsicum frutescens</i>	1.36	1.16	1.09	0.81	1.10
<i>Capsicum chinense</i>	1.51	1.48	1.51	1.14	1.41
Means of soaking time	1.42	1.25	1.25	0.86	
Standard Error	0.11				
Tukey HSD (0.05)	0.18				
<b>Emergence index</b>					
<i>Capsicum annuum</i>	6.45	5.59	5.96	5.49	6.00
<i>Capsicum frutescens</i>	6.83	8.04	7.11	6.58	7.14
<i>Capsicum chinense</i>	7.84	7.73	8.42	8.34	8.08
Means of soaking time	7.21	7.12	7.16	6.81	
Standard Error	0.43				
Tukey HSD (0.05)	0.71				
<b>Emergence rate index</b>					
<i>Capsicum annuum</i>	0.11	0.11	0.10	0.23	0.14
<i>Capsicum frutescens</i>	0.09	0.12	0.14	0.18	0.13
<i>Capsicum chinense</i>	0.10	0.11	0.16	0.17	0.14
Means of soaking time	0.10	0.12	0.13	0.19	
Standard Error	0.02				
Tukey HSD (0.05)	0.03				

*Capsicum frutescens* while *Capsicum annuum* gave the lowest (53%) whereas overall soaking time gave the highest (71) and 18 h gave the lowest emergence (43%). For energy of emergence, *Capsicum chinense* had highest (67%) compared to *Capsicum annuum* (55%) and *Capsicum frutescens* (53%) at 0 h soaking time. At 6, 12 and 18 h soaking time, *Capsicum chinense* consistently gave the highest energy of emergence compared to the other two species, while *Capsicum annuum* recorded the lowest energy of emergence.

The effect of hydropriming treatment duration on seedling vigour, emergence index and emergence rate index over three *Capsicum* species is presented in Table 2. In terms of seedling vigour, *Capsicum chinense* had the highest values compared to the other species at 0, 6, 12 and 18 h soaking time while *Capsicum frutescens*

Table 3: Correlation coefficients among seed physiological characters of three pepper species over four soaking treatments

Seed quality Characters	Seedling emergence	Seedling			Emergence rate index	Emergence index
		Energy of emergence	vigour index	Emergence index		
<b><i>Capsicum annuum</i></b>						
Seedling emergence	1.0	0.936**	0.929**	-0.622**	0.498*	
Energy of emergence		1.0	0.903**	-0.375*	0.741**	
Seedling vigour index			1.0	-0.522*	0.536*	
Emergence rate index				1.0	0.261ns	
Emergence index					1.0	
<b><i>Capsicum frutescens</i></b>						
Seedling emergence	1.0	0.879**	0.925**	-0.809**	0.311ns	
Energy of emergence		1.0	0.844**	-0.502**	0.685**	
Seedling vigour index			1.0	-0.721**	0.338ns	
Emergence rate index				1.0	0.204ns	
Emergence index					1.0	
<b><i>Capsicum chinense</i></b>						
Seedling emergence	1.0	0.955**	0.902**	-0.880**	0.074ns	
Energy of emergence		1.0	0.861**	-0.773**	0.313ns	
Seedling vigour index			1.0	-0.730**	0.051ns	
Emergence rate index				1.0	0.213ns	
Emergence index					1.0	

\*\*Correlation is highly significant, \*Correlation is significant ns: Non significant

recorded the lowest seedling vigour (1.36) at 0 h soaking time whereas *Capsicum annuum* consistently had the lowest values at 6, 12 and 18 h of water soaking. On the overall mean of species, *Capsicum chinense* seed gave the highest seedling vigour (1.41) while the two other species had similar values whereas the mean of soaking time indicated that time of 6 and 12 h had significantly similar seedling vigour index. With emergence index, *Capsicum chinense* consistently had the highest emergence index at 0, 12 and 18 h soaking time followed by *Capsicum frutescens*. However, at 6 h soaking time, *Capsicum frutescens* gave the highest emergence index (8.04 days) over the other two species. *Capsicum chinense* had the highest emergence index at 0 and 18 h soaking time. Across the soaking hours, significant highest emergence index was recorded with *Capsicum chinense* (8.08 days). For emergence rate index, *Capsicum annuum* had the highest value (0.23 days) at 18 h soaking time as compared to the value obtained with *Capsicum chinense* (0.17 days).

Table 3 shows the correlation coefficients among seed quality characters of three *Capsicum* species. For *Capsicum annuum*, seedling emergence had a highly significant and positive correlations with energy of emergence ( $r = 0.936$ ) and seedling vigour index ( $r = 0.929$ ), but had significant positive correlation with emergence index ( $r = 0.498$ ) but had a highly significant negative correlation with emergence rate index ( $r = -0.622$ ). Energy of emergence had a highly significant and positive correlations with seedling vigour index ( $r = 0.903$ ) and emergence rate index ( $r = 0.741$ ). Similarly, seedling vigour index had a significant negative correlations with emergence rate index ( $r = -0.522$ ) and a significant positive

Table 4: Effect of hydropriming treatment duration on seedling emergence and energy of emergence of light graded seeds in three pepper species over two trials

Species	Soaking time (hours)				Mean of species
	0	6	12	18	
<b>Seedling emergence</b>					
<i>Capsicum annuum</i>	38	23	31	51	35
<i>Capsicum frutescens</i>	57	43	35	58	48
<i>Capsicum chinense</i>	39	40	45	61	46
Means of soaking time	44	35	37	57	
Standard Error	4.18				
Tukey HSD (0.05)	6.94				
<b>Emergence index</b>					
<i>Capsicum annuum</i>	17	11	11	30	17
<i>Capsicum frutescens</i>	40	27	26	36	32
<i>Capsicum chinense</i>	19	28	36	43	31
Means of soaking time	25	22	25	36	
Standard Error	4.40				
Tukey HSD (0.05)	7.30				

correlations with emergence index ( $r = 0.536$ ). With *Capsicum frutescens*, seedling emergence had a highly significant positive correlations with energy of emergence ( $r = 0.879$ ) and seedling vigour index ( $r = 0.925$ ) but a highly significant negative correlations with emergence rate index ( $r = -0.809$ ). Similarly, energy of emergence had a highly significant positive correlations with seed vigour index ( $r = 0.844$ ) and emergence index ( $r = 0.685$ ) but had a significant negative correlations with emergence rate index ( $r = -0.502$ ). Seedling vigour index recorded a highly significant negative correlations with emergence rate index ( $r = -0.721$ ). In respect to *Capsicum chinense*, seedling emergence had highly significant positive correlations with energy of emergence ( $r = 0.955$ ) and seedling vigour index ( $r = 0.902$ ) whereas it recorded significant negative correlations with emergence rate index ( $r = -0.880$ ). Similarly, energy of emergence had a highly significant positive correlations with seedling vigour index ( $r = 0.861$ ) but had a highly significant negative correlations with emergence rate index ( $r = -0.773$ ). Also seedling vigour index had a highly significant negative correlations with emergence rate index ( $r = -0.730$ ).

**Hydropriming and seed quality of light density seeds of three *Capsicum* species:** Table 4 shows the effect of hydropriming treatment duration on seedling emergence and energy of emergence of light density seeds in three pepper species over two trials. In terms of seedling emergence, at 0 and 6 h soaking time, *Capsicum frutescens* had the highest value (57%), whereas the two other species had statistically similar emergence values. At 12 h soaking time, *Capsicum chinense* had the highest value (45%) while *Capsicum chinense* and *Capsicum frutescens* recorded higher seedling emergence of 61 and 58% at 18 h

Table 5: Effect of hydropriming treatment duration on, seedling vigour, emergence index and emergence rate index of light graded seeds in three pepper species over two trials

Species	Soaking time (hours)				Mean of species
	0	6	12	18	
<b>Seedling vigour index</b>					
<i>Capsicum annuum</i>	0.69	0.38	0.66	1.03	0.69
<i>Capsicum frutescens</i>	1.17	0.89	0.76	1.22	1.01
<i>Capsicum chinense</i>	0.65	0.85	1.09	1.34	0.98
Means of soaking time	0.84	0.71	0.84	1.19	
Standard Error	0.19				
Tukey HSD (0.05)	0.31				
<b>Emergence index</b>					
<i>Capsicum annuum</i>	4.35	4.64	2.70	4.82	4.13
<i>Capsicum frutescens</i>	6.36	5.59	6.22	5.72	5.97
<i>Capsicum chinense</i>	4.35	5.81	6.35	6.75	5.81
Means of soaking time	5.02	5.35	5.09	5.76	
Standard Error	0.56				
Tukey HSD (0.05)	0.93				
<b>Emergence rate index</b>					
<i>Capsicum annuum</i>	0.17	0.29	0.09	0.08	0.16
<i>Capsicum frutescens</i>	0.13	0.13	0.19	0.11	0.14
<i>Capsicum chinense</i>	0.13	0.17	0.16	0.16	0.15
Means of soaking time	0.14	0.19	0.14	0.12	
Standard error	0.05				
Tukey HSD (0.05)	0.03				

soaking. Across the overall mean species, *Capsicum frutescens* and *Capsicum chinense* had the highest values of 48 and 46 respectively. In terms of energy of emergence, *Capsicum frutescens* had the highest value (40%) at 0 h whereas at 12 and 18 h soaking time, *Capsicum chinense* had the highest energy of emergence 36 and 43%. *Capsicum annuum* recorded the lowest energy of emergence at each soaking hours. The overall mean of species showed *Capsicum frutescens* and *Capsicum chinense* had highest emergence index of 32 and 31%, respectively, while for overall means of soaking time, 18 h gave the highest for emergence index (36 days) of that soaking time.

The effect of soaking treatment duration on seedling vigour index, emergence rate index of light graded seeds in three *Capsicum* species is presented in Table 5. With the seedling vigour, at 0 and 6 h soaking hours, *Capsicum frutescens* had the highest values (1.17 and 0.89, respectively), it was closely followed by *Capsicum annuum* (0.69) and *Capsicum chinense* (0.84) at 0 hr soaking time. Also at 12 and 18 h soaking time, *Capsicum chinense* had the highest values closely followed by *Capsicum frutescens*. After 6, 12 and 18 h soaking time *Capsicum annuum* recorded the lowest seedling vigour index. In term of emergence index, *Capsicum frutescens* had the highest value (6.35 days) at 0 h while *Capsicum annuum* and *Capsicum chinense* had similar values (4.35 days). At 6, 12 and 18 h soaking time *Capsicum chinense* consistently recorded the

Table 6: Correlation coefficients among seed quality characters of light weight seeds of three pepper species over four soaking treatments

Seed quality character	Energy of emergence	Seedling vigour index	Emergence rate index	Emergence index
<b><i>Capsicum annuum</i></b>				
Seedling emergence	0.765**	0.885**	0.188*	-0.663**
Energy of emergence		0.803**	0.463**	-0.290ns
Seedling vigour index			0.239ns	-0.568**
Emergence rate index				0.398*
<b><i>Capsicum frutescens</i></b>				
Seedling emergence	0.837**	0.876**	0.478**	-0.584**
Energy of emergence		0.918**	0.832**	-0.269ns
Seedling vigour index			0.684**	-0.431**
Emergence rate index				0.178ns
<b><i>Capsicum chinense</i></b>				
Seedling emergence	0.838**	0.881**	0.448**	-0.304ns
Energy of emergence		0.956**	0.811**	-0.045ns
Seedling vigour index			0.722**	-0.080ns
Emergence rate index				0.282ns

\*\*Correlation is highly significant, \*Correlation is significant, ns: Non significant

highest emergence index closely followed by *Capsicum frutescens*, with *Capsicum frutescens* having the lowest values at these soaking times.

In terms of emergence rate index, *Capsicum annuum* recorded the highest value at 0 and 6 h soaking time followed by *Capsicum chinense* and *Capsicum frutescens*. At 12 h soaking time *Capsicum frutescens* recorded the highest value (0.19 days) followed by *Capsicum chinense* (0.16 days) while *Capsicum annuum* (0.09 days) gave the lowest value. However after 18 h soaking time, *Capsicum chinense* gave the highest value (0.16 days) followed by *Capsicum frutescens* (0.11 days) whereas *Capsicum annuum* (0.08 days) gave the lowest days.

Correlation coefficients among seed quality characters of light density seeds of three pepper species over four soaking treatments are shown in Table 6. With *Capsicum annuum*, seedling emergence had a highly significant positive correlations with energy of emergence ( $r = 0.765$ ) and seedling vigour index ( $r = 0.885$ ) whereas seedling emergence had a highly significant negative correlations with emergence index ( $r = -0.663$ ). For energy of emergence, a highly significant positive correlations was obtained with seedling vigour index ( $r = 0.803$ ) and emergence rate index ( $r = 0.463$ ). Also seedling vigour index had a highly significant negative correlations with emergence index ( $r = -0.568$ ) whereas emergence index had a significant positive correlations with emergence index ( $r = 0.398$ ). In respect to *Capsicum frutescens* (Table 6), seedling emergence had a highly significant and positive correlations with energy of emergence ( $r = 0.837$ ), seedling vigour index ( $r = 0.876$ ) and emergence rate index ( $r = 0.478$ ) but recorded highly significant negative correlations with emergence index ( $r = -0.584$ ). Similarly, energy of emergence recorded highly significant positive correlation with seedling vigour index ( $r = 0.918$ ) and

Table 7: Effect of hydropriming treatment duration on seedling emergence and energy of emergence of heavy density seeds in three pepper species over two trials

Species	Soaking time (hours)				Mean of species
	0	6	12	18	
<b>Seedling emergence</b>					
<i>Capsicum annuum</i>	60.00	47.00	36.00	39.00	45.38
<i>Capsicum frutescens</i>	55.00	40.00	42.00	36.00	43.22
<i>Capsicum chinense</i>	57.00	54.00	40.00	39.00	47.31
Means of soaking time	57.00	47.00	39.21	38.00	
Standard Error	6.99				
Tukey HSD (0.05)	1.60				
<b>Energy of emergence</b>					
<i>Capsicum annuum</i>	42.00	30.00	24.00	22.00	29.25
<i>Capsicum frutescens</i>	37.00	26.00	11.00	21.00	23.69
<i>Capsicum chinense</i>	47.00	48.00	32.00	35.00	40.41
Means of soaking time	42.08	34.42	22.08	25.75	
Standard error	5.44				
Tukey HSD (0.05)	9.03				

emergence rate index ( $r = 0.832$ ). Seedling vigour index recorded a highly significant positive correlations with emergence rate index ( $r = 0.684$ ) and a highly significant negative correlations with emergence index ( $r = -0.431$ ).

Similarly, for *Capsicum chinense* (Table 6), seedling emergence had highly significant positive correlations with energy of emergence ( $r = 0.838$ ), seedling vigour index ( $r = 0.881$ ) and emergence rate index ( $r = 0.448$ ). Similarly, energy of emergence had highly significant positive correlations with seedling vigour index ( $r = 0.956$ ) and emergence index ( $r = 0.811$ ). In the same vein, seedling vigour index had highly significant positive correlations with emergence rate index ( $r = 0.722$ ).

**Hydropriming and seed quality of heavy density seeds of three *Capsicum* species:** Table 7 shows the effect of hydropriming treatment on seed emergence and energy of emergence of heavy graded seeds in three species of pepper over two trials. In respect to seedling emergence, at 0 h soaking time *Capsicum annuum* had the highest value (60%), while *Capsicum frutescens* (55%) had the lowest emergence. Similarly, at 6 h soaking time, *Capsicum chinense* had the highest value (54%) while *Capsicum frutescens* had the lowest value (40%), *Capsicum frutescens* gave the highest (42%) after 12 h soaking and the lowest emergence was recorded by *Capsicum annuum* (36%). Also after 18 h soaking time, *Capsicum chinense* and *Capsicum annuum* had similar values (39%) while *Capsicum frutescens* had 36% emergence. Data on the mean of species showed that *Capsicum chinense* recorded the highest emergence (47.31%). With energy of emergence, *Capsicum chinense* had higher value (47%) at 0 hr soaking time whereas *Capsicum frutescens* (37%) gave the lowest value. At 6, 12 and 18 hrs soaking time *Capsicum chinense* recorded the highest value closely followed by *Capsicum annuum*

Table 8: Effect of soaking treatment duration on seedling vigour, emergence index and emergence rate index of heavy graded seeds in three pepper species over two trials

Species	Soaking time (hours)				Mean of species
	0	6	12	18	
<b>Seedling vigour index</b>					
<i>Capsicum annuum</i>	1.29	0.97	0.81	0.67	0.93
<i>Capsicum frutescens</i>	0.99	0.83	0.69	0.74	0.81
<i>Capsicum chinense</i>	1.06	0.95	0.86	0.89	0.94
Means of soaking time	1.11	0.92	0.78	0.77	
Standard Error	0.17				
Tukey HSD (0.05)	0.28				
<b>Emergence index</b>					
<i>Capsicum annuum</i>	5.46	5.44	4.91	4.81	5.16
<i>Capsicum frutescens</i>	6.47	5.49	5.58	5.62	5.15
<i>Capsicum chinense</i>	7.28	7.03	7.19	7.33	7.21
Means of soaking time	6.41	5.99	5.89	5.92	
Standard Error	0.61				
Tukey HSD (0.05)	1.01				
<b>Emergence rate index</b>					
<i>Capsicum annuum</i>	0.28	0.22	0.26	0.29	0.26
Standard Error	0.03	0.15	0.25	0.48	0.26
<i>Capsicum chinense</i>	0.25	0.14	0.59	0.24	0.30
Means of soaking time	0.23	0.17	0.37	0.34	
Standard Error	0.14				
Tukey HSD (0.05)	0.23				

while *Capsicum frutescens* recorded the lowest energy of emergence at 0, 6, 12 and 18 h soaking time. On the mean of species, *Capsicum chinense* had the highest (40.41%) while the lowest value of 23.69% was obtained with *Capsicum frutescens*.

Effect of hydropriming treatment duration on seedling vigour, emergence index and emergence rate index of heavy density seeds in three *Capsicum* species over two trials is presented in Table 8. For seedling vigour, *Capsicum annuum* and *Capsicum chinense* had the highest at 0 hr soaking time while the lowest value was recorded with *Capsicum frutescens* (0.99). Unexpectedly, the three *Capsicum* species had statistically similar seedling vigour level. With emergence index after 0 h, *Capsicum chinense* and *Capsicum frutescens* had statistically similar and higher values while *Capsicum annuum* gave the lowest value (5.46 days). After 6, 12 and 18 h soaking, *Capsicum chinense* consistently recorded the highest values followed by *Capsicum frutescens* while *Capsicum annuum* had the lowest values. The overall mean species data showed that *Capsicum chinense* gave the highest value of 7.12 days.

In terms of emergence rate index, statistically similar values were obtained at 0 and 6 h whereas after 12 h (0.59 index) and 18 h (0.48 index), *Capsicum chinense* and *Capsicum frutescens* recorded the highest value, respectively.

Correlation coefficients among seed quality characters of heavy density seeds of three *Capsicum*

Table 9: Correlation coefficient among seed quality characters of heavy graded seeds of three pepper species after four soaking treatments

Seed quality Character	Energy of emergence	Seedling vigour index	Emergence rate index	Emergence index
<b><i>Capsicum annuum</i></b>				
Seedling emergence	0.872**	0.890**	0.384*	-0.434*
Energy of emergence		0.899**	0.703**	-0.260**
Seedling vigour index			0.521**	-0.356*
Emergence rate index				0.172ns
<b><i>Capsicum frutescens</i></b>				
Seedling emergence	0.633**	0.951**	-0.020ns	-0.469**
Energy of emergence		0.639**	0.467**	-0.253ns
Seedling vigour index			0.062 <sup>s</sup>	-0.420**
Emergence rate index				0.434**
<b><i>Capsicum chinense</i></b>				
Seedling emergence	0.724**	0.896**	0.259ns	-0.453**
Energy of emergence		0.660**	0.588**	-0.285ns
Seedling vigour index			0.30ns	-0.365*
Emergence rate index				0.253ns

\*\*Correlation is highly significant, \*Correlation is significant, ns: Non significant

species after four soaking treatments are shown in Table 9. For *Capsicum annuum*, seedling emergence had highly significant positive correlations with energy of emergence ( $r = 0.872$ ) and seedling vigour index ( $r = 0.890$ ), but had significant positive correlation with emergence rate index ( $r = 0.384$ ) and significant negative correlations with emergence index ( $r = -0.434$ ). Similarly, energy of emergence recorded highly significant positive correlations with seedling vigour index ( $r = 0.899$ ) and emergence rate index ( $r = 0.703$ ). Seedling vigour index had a highly significant positive correlations with emergence rate index ( $r = 0.521$ ) but had a significant negative correlations with emergence index ( $r = -0.356$ ). With respect to *Capsicum frutescens*, seedling emergence recorded a highly significant positive correlations with energy of emergence ( $r = 0.633$ ), seedling vigour index ( $r = 0.951$ ) whereas seedling emergence had highly significant negative correlations with emergence index ( $r = -0.469$ ). Similarly, a highly significant positive correlations occurred between energy of emergence and seedling vigour index ( $r = 0.639$ ) as well as emergence rate index ( $r = 0.467$ ). For seedling vigour index, a highly significant negative correlations was obtained with emergence index ( $r = -0.420$ ) while emergence rate index had highly significant positive correlations with emergence index ( $r = 0.434$ ). With *Capsicum chinense*, seedling emergence had highly significant positive correlations with energy of emergence ( $r = 0.724$ ), seedling vigour index ( $r = 0.896$ ) but had a highly significant negative correlations with emergence index ( $r = -0.453$ ). Also energy of emergence recorded a highly significant positive correlations with seedling vigour index ( $r = 0.660$ ) and emergence rate index ( $r = 0.588$ ) whereas seedling vigour index had significant negative correlations with emergence index ( $r = -0.365$ ).

## DISCUSSION

Seed density and hydropriming could have great impact on production, quality and performance of crops. There were highly significant differences among the species and soaking time in most of the characters examined in the ungraded seeds of *Capsicum* species.

Among the species, *Capsicum chinense* had the highest seedling emergence, energy of emergence, seedling vigour index and emergence index. Regarding the effect of hydropriming duration, seeds of *Capsicum chinense* primed in water for 6, 12 and 18 h consistently recorded the highest seedling emergence, energy of emergence and seedling vigour index while *Capsicum annuum* had lowest number of days to germination as indicated by emergence index. Hydropriming for 6 h gave the highest seedling emergence, energy of emergence and seedling vigour index. Moosavi *et al.* (2012) observed a significant difference in hydropriming durations of 8, 12 and 20 h in respect of seed germination in soybean and found soaking in water for 8 h to be the best for improved germination. Positive and significant correlations were found between seedling emergence or energy of emergence and seedling vigour index in each of the three species indicating it was obvious that selection for seed of high emergence will positively affect energy of emergence and seedling vigour index. Perry, (1977), Kraak *et al.* (1984), Durrant *et al.* (1985) and Adebisi *et al.* (2003) had earlier reported strong correlation between seed emergence and seedling vigour index. Therefore, in this present report, seedling emergence or energy of emergence can be taken as a reliable predictor of seedling vigour in ungraded seeds of *Capsicum* species.

For the light density seeds, *Capsicum chinense* consistently gave the highest seedling emergence, energy of emergence, seedling vigour index and emergence index. Similarly, on the effect of soaking time, *Capsicum chinense* primed in water for 6, 12 and 18 h consistently had the highest seedling emergence, energy of emergence, seedling vigour index and emergence index while *Capsicum annuum* had the lowest number of days to germination at 12 h soaking time as indicated by emergence index. Across the hydropriming treatments, it was observed that increase in hydropriming time would lead to an increase in the seedling emergence, energy of emergence, seedling vigour index and emergence index. Positive and significant correlations were found between seedling emergence or energy of emergence and seedling vigour index in each of the three species.

Among the species in heavy density seeds, of *Capsicum chinense* had the highest seedling emergence,

energy of emergence and emergence index. The effect of hydropriming duration indicated that *Capsicum chinense* soaked in water for 6, 12 and 18 h consistently recorded the highest seedling emergence and energy of emergence. After 6 h soaking time, *Capsicum annuum* had the highest seedling vigour index, whereas at 12 and 18 h soaking time, *Capsicum chinense* had the highest seedling vigour index. Positive and significant correlations were found between seedling emergence or energy of emergence and seedling vigour index in each of the three species of heavy seeds.

## CONCLUSION

There were differential responses among the three *Capsicum* species and hydropriming durations in most of the traits. Ungraded, light and heavy density seeds of *Capsicum chinense* had superior seedling emergence, energy of emergence, seedling vigour and emergence index.

Seed hydropriming for 6 and 18 hrs did not improve the seedling emergence and seedling vigour traits above control. However, seed soaking for 0-12 h resulted in lower days to emergence.

In light density seeds, increase in soaking time increased the seedling emergence, energy of emergence, seedling vigour index and emergence index. Soaking of heavy density seeds resulted in higher number of days to emergence when compared to light density seeds. Positive and significant correlations were found between seedling emergence or energy of emergence and seedling vigour index in each of the three species.

Soaking of seed of *Capsicum* species in water for 6 h is recommended in order to improve seed physiological quality. Soaking hours exceeding 6 h would significantly reduce the seedling emergence and seedling vigour traits of *Capsicum* species. Further studies involving chemical or salt priming is necessary in seed quality assessment in *Capsicum* species.

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