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INFLUENCE OF HYDROPRIMING ON GERMINATION AND SEEDLING EMERGENCE OF GREEN BELL PEPPER (*Capsicum annum cv.* Goliath)

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ABSTRACT
A laboratory experiment was conducted in the Department of Agricultural Technology, Enugu State Polytechnic, Iwollo, to evaluate the influence of hydro-priming on germination and seedling emergence of green bell pepper (Capsicum annum cv. Goliath). The hydro-priming treatments were; control, 6, 12, 18, and 24 hours. The experiment was laid in Completely Randomized Design (CRD) with three replications. Data on germination and emergence indices were collected and analyzed using analysis of variance (ANOVA). The treatment means that were significant were separated using least significant difference under 0.05 probability level. The results showed that hydro-priming significantly ($p<0.05$) increased coefficient of velocity of germination (CVG), coefficient of velocity of emergence (CVE), coefficient of uniformity of emergence (CUE) and emergence percentage (EP) with 24 hours having superior values and the least values in control. Hydro-priming also significantly decreased mean germination time (MGT), mean emergence time (MET), days to 50% germination (D50G) and days to 50% emergence (D50E) with the least values obtained in 24hr and highest values in control. However, hydro-priming did not significantly ($p>0.05$) influence germination percentage (GP) and coefficient of uniformity of germination (CUG) though improved values were obtained in hydro-primed seeds compared to un-primed seeds. It can be concluded that hydro-priming significantly improved germination and seedling emergence of green pepper. The optimal hydro-priming time for green pepper was 24hours, which enhanced the germination and emergence percentage**,** ensured early germination and seedling emergence, increased uniformity of emergence, and increased seedling vigour.

KEY WORDS: *Capsicum annum* L., Germination, hydro priming, Seedling emergence.

INTRODUCTION

Green pepper is botanically fruit but is generally considered in culinary context to be vegetable (Garcia-closas *et al.*, 2004). While green pepper is a cultivar of the *Capsicum annum* (Sweety, 2013); it belongs to the cultivar group known as bell pepper or sweet pepper which is the only capsicum which does not produce capsiacin, a lipophilic chemical that can cause a strong burning sensation when it comes in contact with mucous membrane (Kumar *et al.*, 2011). The lack of capsiacin in green pepper is due to a recessive form of a gene that eliminates capsiacin and consequently the "hot" taste usually associated with the rest of the capsicum genus (Kumar *et al.*, 2011). Green pepper has characteristic distinctive aroma and colour. Both characters increase its use as culinary in diet such as salad, fried rice etc. and constitute the high selling points of the fruit in urban markets. Green pepper is not very common in Africa, but increasingly important in urban market where green pepper fruit are worth N500-N600 per kilogramme. Green pepper supplies vitamins, minerals, fibre and help in reducing cholesterol level and increases cardio-vascular efficiency in human (Garcia-closas *et al*, 2004).

Green pepper is a warm climate crop and requires 25-27°C for optimum seed germination and emergence (Hartmann *et al*., 1988). Green pepper cultivation in commercial scale is not common in African. Grubber and El Tahir (2004) reported that high disease infestation and pest attack make green pepper cultivation difficult in hot and humid tropical low land of Africa. The high incidence infestation and high pest attack have often discouraged farmers from going into commercial green pepper production in South-eastern zone of Nigeria characterized by high humid condition. This problem is often compounded by green pepper nursery failure. The green pepper nursery failure is usually associated to low seed quality and low vigour seeds - implications of long seed storage and age related cellular and sub-cellular damage that may accumulate during seed development (Bray, 1995). Generally, seed storage causes a decrease in the protein content which may be related to oxidation of the amino acids due to the increase in the respiratory activity and advance in the deterioration process of the seeds (McDonald, 1999). Green pepper takes longer time to germinate and emerge (10-14days) compared to other capsicum species (6-8days). Most often, when seedling emergence sets off, it is slow and not uniform. The delayed emergence also increases the chance of the seedlings being infected by damping-off causing pathogens.

Rapid and uniform germination and emergence of green pepper is important in green pepper production. It is the foundation on which stand establishment is based and potential yield is determined. One programmatic approach to increase good stand establishment and increase crop production is seed invigouration (Farooq *et al.,* 2006). Seed priming as an effective seed invigouration method has become a common seed treatment to increase the rate of uniformity of germination and seedling emergence and crop establishments in most crops especially in advance countries. According to Khan (1992), seed priming is a controlled hydration process that involves exposing the seed to low water potentials that restrict germination, but permits pre-germination physiological and chemical changes to occur. Hossein (2013) defined seed priming as a controlled hydration process followed by re-drying that allows seed to imbibe water and begin internal biological processes necessary for germination, but which does not allow the seed to actually germinate. Seed priming is a pre-sowing strategy for influencing seedling development by modulating pre-germination metabolic activity prior to emergence of the radical and generally enhances rapid, uniform emergence and plant performance to achieve high vigour and better yields (McDonald, 2000). Priming of seed promotes germination by repair of the damaged protein, RNA and DNA (Koehler *et al*, 1997). The promotion of germination and seedling emergence with seed priming may take place for several reasons, but changes in metabolic levels are important during priming. During priming, seeds are soaked in different solutions with high osmotic potential so that pre-germination metabolic activities proceed, while radical protrusion is prevented, and then seeds are dried back to the original moisture level. Upon rehydration, primed seeds may exhibit faster rates of germination, more uniform emergence, and greater tolerance to environmental stress and reduced dormancy in many species (Khan, 1992). Common priming techniques include osmo-priming (soaking seeds in osmotic solutions such as polyethylene glycol), halo-priming (soaking seeds in salt solution) and hydro-priming (soaking seeds in water). Among all the methods of seed priming, soaking and misting seeds in water and re-drying them before they complete germination (hydro-priming) is the simplest approach to hydrating seeds (McDonald, 2000). Several literatures revealed that seed priming could advance germination in wide range of temperature, break seed dormancy, improve the initial quality characters, improve uniformity in emergence, better establishment of crop stands and increase yield in many diverse environments. Bradford (1986) revealed that seed priming has been successfully demonstrated to improve germination and emergence in many crops particularly seeds of vegetables. Harris *et al* (1999) revealed that on-farm seed hydro-priming markedly improve the establishment and early vigour of maize resulting in faster development and higher yield. Kaur *et al.,* (2003) observed that priming chickpea seeds with water caused early germination, increased seedling length, maximum biomass of root and shoot under salt stressed conditions. Basra *et al.,* (2003) in wheat found that hydro-priming for 24h and hardening for 12h were found better as expressed by germination and all other vigour parameters compared to halo priming with 100 mol m^{-3} $CaCl_2$ for 24h. At present, no priming technique has been recommended to ensure early and uniform seed germination and seedling emergence and increase green pepper production in south-eastern Nigeria. The objective of this study therefore, was to assess the influence of hydro-priming on germination and seedling emergence of green bell pepper (*Capsicum annum* L. cv. Goliath).

MATERIALS & METHODS

Description of Experimental Site

The study was carried out in the laboratory and inside poly-house at Enugu State Polytechnic, Iwollo. The Study area was located in south-east agro-ecological zone of Nigeria; geographical co-ordinate N6° 27^{I} and E7° 17^{I}. The rainfall distribution pattern is bimodal with peaks in July and September, and short dry period around mid August (August break). The mean annual rain fall ranges between 1500 – 1900 mm with a mean maximum and minimum temperatures of 31°C and 29°C and relative humidity of 69 - 79% , respectively (Uguru, 2011).

Seed Preparation

Green pepper seeds of cultivar Goliath that can be grown in Southeastern Nigeria were used in the study. The seeds were treated with 1.0% solution of sodium hydrochloride for surface sterilization. Residual chlorine was eliminated through washing of the seeds with distilled water.

Hydro-priming Treatments

The seeds were soaked in distilled water for 6hrs, 12hrs, 18hrs and 24hrs at room temperature. The primed seeds were dried on a filter paper and back to their original state. Un-primed seeds served as control.

Experimental Design and Treatments arrangement

Completely Randomized Design (CRD) was used for the study. The treatments were replicated three times both for seed germination and seedling emergence studies.

Germination Studies

Twenty seeds from each of the treatments were germinated in Petri dishes which contained two layers of filter papers that were wetted with 10ml of distilled water. Germination was considered to have been occurred when the radicles were 2mm long (Moghanibashi *et al.,* 2012). Petri dishes were observed every 24hrs for 14 days and germinated seeds counted.

Germination Percentage (GP)

Data on germination percentage was recorded every 24hrs for 14days. This was evaluated by counting the number of normal seedlings at the end of the germination test.

$$\text{GP} = \frac{\text{seeds germinated}}{\text{Total seeds}} x\ 100$$

Mean Germination Time (MGT)

Mean Germination Time was evaluated using the formula:

$$\overline{D} = 100/\{(\sum_{i=1}^{k} ni/\sum_{i=1}^{k} Dini)100\}$$

Where:

ni : number of seeds germinated on the *i*th day

Di : number of days counted from the day of sowing to the collection of the datum (*i*), and;

k: last day of germination. (Bewley and Black, 1994)

Days to 50% Germination (D50%G)

Days to 50% germination were calculated from the date of sowing to date half of the seeds germinated by counting seeds germinated in each Petri dish daily.

Coefficient of Velocity of Germination (CVG)

Coefficient of velocity of germination was evaluated using the formular:

$$CVG = (\sum_{i=1}^{k} ni / \sum_{i=1}^{k} Dini)100$$

Where:

ni : number of seeds germinated on the *i*th day

Di : number of days counted from the day of sowing to the collection of the datum (*i*), and;

k: last day of germination. (Bewley and Black, 1994)

Coefficient of Uniformity of Germination (CUG)

Coefficient of uniformity of germination was evaluated using the formular:

$$CUG = \sum_{i=1}^{k} ni / \sum_{i=1}^{k} (\overline{D} - Di)^2 ni$$

Where:

ni : number of seeds germinated on the *i*th day,

Di : number of days counted from the day of sowing to the collection of the datum (*i*),

$\overline{D}$: mean germination time and;

k: last day of germination. (Bewley and Black, 1994)

Emergence Studies

Twenty seeds from each of the treatments were sown in nursery boxes with nursery mixture of soil, well cured poultry manure and sand in the ratio of 3:2:1 respectively. The nursery boxes were placed inside the poly-house with blue polythene. The nursery boxes were watered daily; morning and evening with equal quantity of water.

Emergence Percentage (EP)

Data on emergence percentage was recorded every 24hrs for 14days and was evaluated by counting the number of normal seedlings emerged at the end of the emergence test.

$$\text{GP} = \frac{\text{seeds emerged}}{\text{Total seeds}} x\ 100$$

Mean Emergence Time (MET)

Mean Emergence Time was evaluated using the formula:

$$\overline{D} = 100/\{(\sum_{i=1}^{k} ni / \sum_{i=1}^{k} Dini)100\}$$

Where:

ni : number of seeds emerged on the *i*th day

Di : number of days counted from the day of sowing to the collection of the datum (*i*), and;

k: last day of emergence. (Bewley and Black, 1994)

Days to 50% Emergence (D50%E)

Days to 50% emergence were determined by recording the days, starting from the sowing date to the date half of the sown seeds emerged.

Coefficient of Velocity of Emergence (CVE)

Coefficient of velocity of emergence was evaluated using the formular:

$$CVE = (\sum_{i=1}^{k} ni / \sum_{i=1}^{k} Dini)100$$

Where:

ni : number of seeds emerged on the *i*th day,

Di : number of days counted from the day of sowing to the collection of the datum (*i*), and;

k: last day of emergence. (Bewley and Black, 1994)

Coefficient of Uniformity of Emergence (CUE)

Coefficient of uniformity of emergence was evaluated using the formular:

$$CUE = \sum_{i=1}^{k} ni / \sum_{i=1}^{k} (\overline{D} - Di)^2 ni$$

Where:

ni : number of seeds emerged on the *i*th day,

Di : number of days counted from the day of sowing to the collection of the datum (*i*),

$\overline{D}$: mean emergence time and;

k: last day of emergence. (Bewley and Black, 1994)

Statistical Analysis

All the data collected were statistically analyzed using analysis of variance (ANOVA) using GenStat Release 10.3DE software (2012). Comparison between means was made using least significant difference (LSD) at 0.05 probability level.

RESULTS

Effect of Hydropriming on Germination of Green Pepper (*Capsicum annum cv.* Goliath)

Results of the analysis of variance as shown in Table1 showed that Germination Percentage and Coefficient of Uniformity of Germination were not significantly *(p>0.05)* influenced by hydro-priming. Days to 50% Germination, Mean Germination Time and Coefficient of Velocity of Germination were significantly *(p<0.05)* influenced by hydro-priming. The highest value of Days to 50% Germination (7.00) was obtained in unprimed seeds (control) while the lowest was obtained in 24 hours hydro-priming. Similarly, the highest Mean Germination Time (7.82) was obtained in unprimed seeds (control), while the lowest value was obtained in 24 hours hydro-priming. On the other hand, the highest Coefficient of Velocity of Germination (20.30) was obtained in 24 hours hydro-priming, while the lowest value was obtained in control treatment. All hydro-priming treatments induced higher Coefficient of Velocity of Germination compared to unprimed seeds (control) in this order; 24hrs> 18hrs> 12hrs> 6hrs>control.

TABLE 1: Effect of hydropriming on germination indices of green bell pepper (*Capsicum annum cv*. Goliath)

Hydro-priming Treatment	GP (%)	D50 % G (day)	MGT (day)	CVG	CUG (day^{-2})
6hrs	78.33	6.67^{ab}	7.44^{a}	13.55^{cd}	0.21
12hrs	83.33	6.33^{ab}	6.59^{b}	15.18^{c}	0.34
18hrs	91.67	5.33^{bc}	5.47^{c}	18.28^{b}	0.34
24hrs	91.67	4.67^{c}	4.95^{c}	20.30^{a}	0.41
Control	76.67	7.00^{a}	7.82^{a}	12.80^{d}	0.19
$LSD_{0.05}$	NS	1.4857	0.7867	1.8931	NS

NS: Non Significant

Mean values within each column with the same letter are not significantly different (p>0.05).
G.P (Germination Percentage), D50%G (Days to 50% germination), MGT (Mean Germination Time), CVG (Coefficient of Velocity of germination), CUG (Coefficient of uniformity of germination)

Lower values of Days to 50% Germination and Mean Germination time obtained in hydro-primed seeds were indications of more uniform and earlier germination. On the other hand, higher Coefficient of Velocity of Germination expressed higher power of germination and seed vigour.

Effect of Hydropriming on Emergence of Green Pepper (*Capsicum annum cv.* Goliath)

Results of the analysis of variance as shown in Table 2 showed significant difference *(p<0.05)* in all the emergence parameters determined. All hydro-priming treatments induced higher Emergence Percentage, Coefficient of Velocity of Emergence and Coefficient of Uniformity of Emergence compared to un-primed treatment (control) in this order; 24hrs> 18hrs> 12hrs> 6hrs>control, except for Emergence Percentage- 24hrs>18hrs>12hrs,6hrs>control where, 12hrs (55) and 6hrs (55) were equal. On the other hand, the unprimed treatment (control) recorded highest values of Days to 50% Emergence (13.33) and Mean Emergence Time (10.90) compared to hydroprimed treatments in this order control>6hrs>12hrs>18hrs>12hrs. Lower values of Days to 50% Emergence and lower values of Mean Emergence Time obtained in hydro-primed seeds are indications of early emergence. On the other hand, the higher values of Emergence percentage, Coefficient of Velocity of Emergence and Coefficient of Uniformity of Emergence obtained in hydro-primed treatments are indications of higher seed vigour, higher power of germination and higher uniformity respectively.

TABLE 2: Effect of hydropriming on emergence indices of green bell pepper (*Capsicum annum cv*. Goliath)

Hydro-priming Treatments	EP (%)	D50%E (day)	MET (day)	CVE	CUE (day^{-2})
6hrs	55^{b}	12.33^{ab}	10.22^{b}	9.80^{c}	0.42^{bc}
12hrs	55^{b}	11.00^{bc}	9.88^{b}	10.13^{c}	0.61^{a}
18hrs	75^{a}	9.33^{c}	7.88^{c}	12.72^{b}	0.65^{a}
24hrs	80^{a}	7.33^{d}	7.31^{c}	13.67^{a}	0.75^{a}
Control	50^{b}	13.33^{a}	10.90^{a}	9.18^{d}	0.35^{c}
$LSD_{0.05}$	8.1221	1.6939	0.6072	0.5895	0.2243

NS: Non Significant
Mean values within each column with the same letter are not significantly different (p>0.05).
E.P (Emergence Percentage), D50%E (Days to 50% Emergence), MET (Mean Emergence Time), CVE (Coefficient of Velocity of Emergence), CUE (Coefficient of Uniformity of Emergence)

DISCUSSION

The evidence in the present study suggested an important role of hydro-priming of Green pepper seeds to enhancing germination and seedling emergence. Seed hydro-priming significantly *(p<0.05)* improved Days to 50% Germination and Emergence; Emergence Percentage; Mean Germination and Emergence time, Coefficient of Velocity of Germination and Emergence; and Coefficient of Uniformity of Emergence as shown in Table1 and Table2. The optimal hydropriming time for green pepper was 24hours, which enhanced the germination and emergence percentage, ensured early germination and seedling emergence, increased uniformity of emergence, and increased seed vigour. Ahmadi *et al*. (2007) found that hydropriming of wheat (*Triticum aestivum*) seeds clearly improved speed of emergence; vigour index and seedling dry weight. Other beneficially effects of hydro-priming were reported in tomato (Khalil and Moursy, 1983), maize (Murungu *et al*., 2004), sunflower (Hussain *et al*., 2006), bean (Abebe and Modi, 2009), lentil (Salglam *et al.*, 2010) and cowpea (Singh *et al*., 2011). The stimulatory effects of hydropriming on the early stage of germination process could be the cause of the positive effects recorded. When dry seed is soaked in water, the uptake of water involves three stages (Varrier *et al*., 2010). According to Bewley (1997), rapid uptake of water occurs in the first stage due to the seed low water potential and in the last stage where the process of germination is completed by the radical emergence. The second stage involves biochemical activities. The effect of priming on improving seed performance might be attributable to the completion of pre-germination process such as DNA replication (Bray *et al*., 1989), increased RNA and protein synthesis (Fu *et al*., 1988), greater ATP availability (Mazor *et al*., 1984), faster embryo growth (Chang *et al*., 2000), repair of deteriorated seed parts (Karssen *et al*., 1989), reduced leakage of metabolites (Ward and Powell, 1983), decrease in lipid peroxidation and increased in the antioxidant activities (Issam *et al*., 2012) compared with control. Hydropriming may also reduce the inhibitory activities of trypsin and chymotrypsin and promote germination and seedling emergence (Bewley and Black, 1994). Seed germination is very sensitive to hydration process; therefore, it seems in tandem with increased hydropriming time to 24hrs. Water uptake rate in priming duration is slow at 24hrs, seeds had enough time to complete the pre-germination process (Varier *et al*., 2010), but not enough to cause suffocation and death of embryo due to lack of oxygen (Finch-Savage *et al.*, 2004). This could explain why optimal germination and emergence was observed in 24hours hydro-priming. The improved seedling emergence in hydro-primed seeds could be an induction of improved germination and seedling vigour. These findings support the earlier studies on rice (Farooq *et al*., 2006; Ibrahim *et al.*, 2013), sunflower (Hussain et al., 2006), wheat (Ahmadi *et al*., 2007), bean (Abebe and Modi, 2009; Ghassemi-Golezani *et al*., 2010), sorghum (Moradi and Younesi, 2009), lentil (Saglam *et al*., 2010), tomato

(Amoaghaie *et al*., 2010), basil (Aliabadi and Maroufi, 2011), bromus (Tavili *et al*., 2011) and cowpea (Singh *et al*., 2011) that have reported hydropriming improved germination and emergence indices.

CONCLUSION & RECOMMENDATION

This study was carried out to evaluate the influence of hydro-priming on germination and seedling emergence of green bell pepper (*Capsicum annum cv.* Goliath). Some germination and emergence indices were evaluated. The findings showed that seed hydro-priming is a very effective technique for improving seed germination and seedling emergence of green bell pepper (*Capsicum annum cv.* Goliath). Hydro-priming for 24 hours is the most effective treatment, while hydro-priming for 6 hour was the least effective treatment among the hydro-priming durations. Improved seed germination and emergence due to hydro-priming may be explained by an increased water uptake and rate of cell division. Hydropriming has been considered as a simple and cost-effective strategy for improving germination and emergence of green pepper (*Capsicum annum*). The findings of this study showed that for optimal germination and emergence of green pepper (*Capsicum annum*), hydro-priming for 24hours is recommended.

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