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PRODUCTIVITY OF WATERMELON (*Citrullus lanatus* Thunb Mansf.) AS AFFECTED BY SEED HARDENING WITH SALICYLIC ACID UNDER RAIN-FED CONDITION

S.U. Yahaya and F.S. Mohammed.

Department of Agronomy, Bayero University, P. M. B. 3011, Kano, Nigeria.

ABSTRACT

Field trials were conducted during 2017 rainy season at Bukavu barracks, Fagge L.G.A, Kano and Tassa village, Dawakin Kudu L.G.A, Kano to study the productivity of watermelon (C*itrullus lanatus*) as affected by seed hardening with salicylic acid under rain-fed condition. Treatments consisted of factorial combination of four concentrations (0, 1.0, 2.0, and 3.0 g L^{-1}) of salicylic acid and two watermelon varieties (Greybell and Kaolack) laid out in a Randomized Complete Block Design with 3 replications. Significant ($p<0.05$) effect of hardening watermelon seeds with salicylic acid was observed in the reduction of days to emergence of watermelon seedlings. This however, did not translate to increased fruit yield. Hardening of water melon seeds with salicylic acid is thus recommended for improved seedling emergence and good stand establishment. Research is thereby suggested on repeated foliar application with salicylic acid to augment the hardened seeds for sustained fruit yield of watermelon under rain-fed condition in the study areas.

Key words: Rain-fed; Salicylic acid; seed hardening; Watermelon.

INTRODUCTION

Watermelon (*Citrullus lanatus* Thunb Mansf.) is a member of Curcubitacea family, originating from the dry regions of southern Africa. It is produced all over the world particularly in the semi-arid regions (Wehner *et al*., 2001). There are over 1,200 varieties of watermelon worldwide and quite a number of these varieties are cultivated in Africa (Zohary and Hopf, 2000). Watermelon is low in calories but highly nutritious and thirst quenching (Mangila *et al*., 2007). It also contains vitamins A and C in form of disease fighting beta-carotene (IITA, 2013).

Seed hardening is a promising technique that has been successfully employed to overcome the problem associated with poor germination and subsequent erratic crop stand under normal and stressful conditions (Farooq *et al.* 2009; Jafar *et al.* 2012; Rehman *et al.* 2011). It is nowadays being extensively used to improve seed germination and seedling survival/ establishment in a wide range of crop species, a requisite for improved yield in crops (Hosseini and Koocheki, 2007). Growth hormones are normally used for seed hardening, including auxin, abscisic acid, polyamines, ethylene, salicylic acid and ascorbic acid (Demiral and Turkan, 2005).

Salicylic acid (SA) is a common plant-produced signal molecule of phenolic nature which participates in the regulation of numerous physiological processes (Shakirova *et al*., 2003). It was known to be a signal molecule in systemic acquired resistance (SAR) in several species (Raskin, 1992). Further, its role is evident in seed germination, fruit yield, glycolysis, flowering in thermogenic plants (Klessig and Malamy, 1994), ion uptake and transport (Harper and Balke, 1981), photosynthetic rate, stomatal conductance and transpiration (Khan *et al*., 2003). In addition to defense responses, salicylic acid is implicated in the regulation of different biological processes, such as seed germination, seedling development, nodulation in legumes, plant vegetative growth, senescence-associated gene expression, flowering time, fruit yield, respiration, as well as response to ultraviolet (UV)-B radiation, ozone, metals, drought, temperature, and salinity stresses (Khan *et al*., 2015; Vlot *et al*., 2009).

Watermelon is produced in the savannas mainly as a cash crop; which often yields low during the rains as compared to dry season. Under irrigation fruit yield can be as high as 72.0 t ha^{-1} (Simonne *et al*., 2004) whereas when grown on rainwater yields can be as low as 3.0 t ha^{-1} (Pala *et al*., 2000). Armin *et al*. (2010) also reported that seed hardening increased watermelon emergence, emergence rate, and plumule length. These also promote good plant establishment, early maturity and hence, improved yields (Ndunguru and Rajabu, 2004).

Several studies have reported the benefits of hardening of watermelon seeds. However, little or no work has been done on the efficacy of hardening watermelon seeds with salicylic acid under rainy conditions. Hence, this research was conducted to determine the effect of seed hardening with salicylic acid on the productivity of watermelon under rain-fed condition.

MATERIALS AND METHODS

Description of the Study Areas

The experiment was conducted during the rainy season of 2017 at Bukavu Barracks, Kano (Latitude 12^0 3'N Longitude 08^0 31'E) at an altitude of 476 m and Tassa village, Dawakin Kudu LGA, Kano (Latitude $11^0$50'N Longitude $08^0$35'E) at an altitude of 450 m, located in the Sudan savanna ecological zone of Nigeria. These locations are characterized by a mean annual rainfall of 300-600mm per annum, high annual average temperature range (28-32°C), short wet season and long dry season (6-9 months), abundant short grasses (< 2 m) and a few scattered trees (Sowunmi and Akintola, 2010).

Soil Sampling and Analysis

Soil samples were randomly collected from 5 spots in each plot at 0 - 30cm depths before the start of the experiment. Composite samples were air-dried, bulked and analyzed for physical and chemical properties using standard procedure as described by Black (1965).

Treatments and Experimental Design

Factorial combinations of four rates of salicylic acid (0, 1.0, 2.0, and 3.0gL^{-1}) and two varieties (Kaolack and Grey Bell) of watermelon as comprised of eight treatments were laid out in a randomized complete block design with four replications.

Varietal Description

Grey Bell and Kaolack were the commonly cultivated varieties by farmers in the study areas and hence the basis of our choice in this study. Grey Bell has circular fruits weighing 7-8kg, with a light green rind color characterized with veins. The flesh is red with light brown seeds. It is high yielding and matures in 80 days. It is also resistant to sun burn and has a strong plant vigor. Kaolack is also characterized by round fruit weighing 5-6kg, with a light green skin color and finely medium green stripes. The red flesh color is crunchy and sweet and well-appreciated by consumers. It has a high yield and tolerance to Anthracnose. Kaolack is famous in sub-Saharan countries and matures in 80-85days.

Salicylic Acid Formulation and Hardening Process

The prescribed salicylic acid (SA) concentrations were formulated by dissolving 1.0, 2.0 and 3.0g each of salicylic acid each in 1litre of distilled water. The watermelon seeds were placed in covered petri-dishes on double layers of filter paper, wetted with 15 ml of the prepared concentrates and the control. These were kept at room temperature in darkness for 24 hours after which the seeds were rinsed.

Cultural Practices

The land was cleared, harrowed and levelled prior to layout and sowing. This was demarcated into 25.5 x 29m. Gross plot size of $18m^2$ (6 x3m) was earmarked with 0.5m borders between plots and 1m between blocks. The net plot size was $9m^2$.

The hardened seeds were sown immediately at the rate of two seeds per hole and also at 3cm soil depth using 1.5m between rows and 1m between stands. The emerged seedlings were thinned to one plant per stand. Manual hoe weeding was done at 3 and 6 weeks after sowing (WAS). NPK 15:15:15 was applied using ring method at 3 WAS at the rate of 150 kg ha^{-1} as recommended by Sabo *et al.* (2013). Lambda-cyhalothrin (Karate 2.5EC) was applied using a knapsack sprayer weekly at the rate of 15g ai ha^{-1} beginning from 3 WAS to control pest infestation during the growing period of the crop. Diseases were curtailed using Ridomil MZ (Mefenoxam and Mancozeb) at the rate of $2kgha^{-1}$. Harvesting was carried out manually with a knife when it was observed that fruit tendrils turned brown, the fruits turned pale yellow at the spot close to the ground and when the sound of the fruit when thumbed with a knock gave a soft hollow sound instead of metallic ringing sound.

Data Collection and Analysis

Four stands from each net plot were randomly tagged. Data were collected from these tagged plants on: days to emergence by recording the actual days it took the hardened seeds to emerge from the date of sowing, number of leaves per plant by counting the actual number of leaves at 8WAS and their mean recorded, vine length (m) by measuring the length of the extended vines from the ground surface to the terminal leaflet at harvest and their mean recorded, number of fruits per plant by counting of numbers of the harvested fruits from each tagged stand and their mean recorded, average fruit weight (kg) from random weights of 10 harvested fruits and their mean recorded and fruit yield (t ha^{-1}) from the cumulative fruit weights of harvested net plots. These were extrapolated to ton ha^{-1} using the following relation:

Fruit yield t ha^{-1} = Total harvested fruit weights x 10,000/ Net plot ($9m^2$).

Data were subjected to analysis of variance using Genstat 17th edition. Significant treatment means were compared using DMRT (Duncan, 1955).

RESULTS AND DISCUSSION

The results of the physical and chemical properties of the soils of the experimental sites are shown in Table 1. This indicated that both soils were sandy loam. The soils were also relatively low in terms of organic carbon (6.8 and 4.7gkg^{-1}) and total nitrogen (10.5 and 8.1gkg^{-1}) at Bukavu and Tassa respectively, hence not suitable for vegetable production without fertilizer application. The soil pH was neutral in Bukavu and slightly acidic in Tassa. The soils of both sites were thus, moderately fertile with the soils of Bukavu being relatively higher in terms of organic carbon, total nitrogen and available phosphorus and hence more fertile than that of Tassa.

Table 1: Physical and chemical properties of the soil at experimental sites at Bukavu and Tassa during 2017 rainy season

Properties	Bukavu	Tassa
Particle Size (gkg^{-1})		
Sand	580.0	692.0
Clay	120.0	188.0
Silt	300.0	120.0
Textural Class	Sandy loam	Sandy loam
Chemical Composition		
pH in water	7.23	6.80
Organic Carbon (gkg^{-1})	6.80	4.70
Total Nitrogen (gkg^{-1})	10.5	8.10
Available phosphorus ($mgkg^{-1}$)	11.55	8.95
Exchangeable cations ($cmolkg^{-1}$)		
Ca++	1.75	1.25
Mg++	1.33	0.87
K+	0.57	0.51
Na+	0.12	0.11
CEC	4.92	4.31

Analyzed at Soil Science Laboratory, Faculty of Agriculture, Bayero University, Kano.

Significant ($p< 0.05$) effects of variety and salicylic acid (SA) was noticed in days to emergence of water melon from both locations as Grey bell took more days to emerge than Kaolack (Table 2). This could be attributed to genetic variation between them. Similar observation was made by Oraegbunam *et al.* (2016) who reported differences in days to emergence of different water melon varieties. The results also showed that water melon seeds hardened with salicylic acid emerged earlier irrespective of the rate applied, while it took the control (untreated) seeds more days to emerge. This corroborated with the findings of

Argerish *et al*. (1989) who reported that seedling emergence of primed seeds as earlier with the emergence more synchronous especially under sub-optimal temperatures. Armin *et al.* (2010) also reported decrease in days to emergence in primed water melon seeds.

The results of the present investigation however, revealed that number of leaves per plant and vine length in water melon were not significantly ($p > 0.05$) influenced by variety and SA treatment in both locations. This result is in contrast with what Szepsi *et al*. (2005) reported, in which significant effect of applied SA was noticed with respect to increased CO_2 assimilation/ photosynthetic rate which translated to increased number of leaves. Ahmad *et al*. (2014) also reported increased number of leaves, leaf area and number of branches with application of SA which also contradicts the outcome of the present results.

Table 2: Influence of variety and salicylic (g l^{-1}) treatments on some agronomic and vegetative characters of watermelon (*Citullus lanatus*) at Bukavu and Tassa during 2017 rainy season

	Bukavu			Tassa		
Treatment	Days to Emergence	Number of Leaves Plant^{-1}	Vine Length (cm)	Days to Emergence	Number of Leaves Plant^{-1}	Vine Length (cm)
Variety (V)						
Grey Bell	4.38a	20.24	203.00	2.38a	22.18	233.00
Kaolack	4.13b	19.98	219.00	2.13b	22.73	249.00
SE±	0.072	0.385	0.137	0.072	0.287	0.137
Salicylic Acid (SA)						
0	5.00a	19.18	228.00	3.00a	22.96	258.00
1.0	4.00b	19.68	220.00	2.00b	22.19	250.00
2.0	4.00b	20.73	226.00	2.00b	22.18	256.00
3.0	4.00b	20.80	170.00	2.00b	22.50	200.00
SE±	0.102	0.544	0.194	0.102	0.405	0.194
Interaction						
VxSA	*	ns	Ns	*	ns	ns

Means followed by the same letter(s) within treatment columns are not significantly different at 5% level of probability using DMRT.

Significant ($p < 0.05$) interactions of variety and SA treatment was observed on days to emergence in water melon from both locations (Table 3). This showed that the SA treated seeds emerged much earlier irrespective of the rate and the variety in both locations. This is an indicative of the role of seed hardening with SA in accelerating seedling emergence as more important than variety as reported by Argerish *et al*. (1989); and Armin *et al*. (2010).

Table 3: Interactions of variety and salicylic treatments on days to emergence in water melon (*Citullus lanatus*) at Bukavu and Tassa during 2017 rainy season

	Days to Emergence at Bukavu				Days to Emergence at Tassa			
	Salicylic Acid (gL^{-1})							
Variety	0	1.0	2.0	3.0	0	1.0	2.0	3.0
Grey Bell	5.50a	4.00c	4.00c	4.00c	3.50a	2.00c	2.00c	2.00c
Kaolack	4.50b	4.00c	4.00c	4.00c	2.50b	2.00c	2.00c	2.00c
SE±	0.144				0.144			

Means followed by the same letter(s) within treatment columns are not significantly different at 5% level of probability using DMRT

Table 4 presents the influence of variety and SA treatment on some selected yield components and fruit yield in water melon at Bukavu and Tassa during 2017 rainy season. This indicated that number of fruits per plant, average fruit weight and fruit yield were not significantly ($p > 0.05$) affected by neither variety nor SA treatment. Similar observation was reported by Damaso (2013) for non-significant response of three water melon varieties (sugar baby, max F1 and jumbo) to fruit diameter, number of fruits, fruit weight and marketable yield. The lack of response could also be ascribed by the similarities in their genotype as well as adaptability to the environment. Similar observation was reported by Majambu *et al*. (1996); and Sajjan *et al*. (2002), who attributed such lack of response to genotypic constitution of the plant. This is also an indication of exhaustion of the efficacy of the applied SA overtime, probably due to rains and/or utilization of the SA by the crop that may warrant repeated foliar application for optimum uptake/ utilization. Nascimento (2003) also reported similar observation, that response of seeds to priming as dependent on osmotica, duration of priming, seed maturity, cultivar and environmental conditions. However, this results is in contrast with what Ndunguru and Rajabu (2004) reported, that primed seeds gave rise to crops which matured earlier with much higher yields.

Table 4: Influence of variety and salicylic (gL^{-1}) treatments on some yield components and fruit yield (ton ha^{-1}) of water melon (*Citullus lanatus*) at Bukavu and Tassa during 2017 rainy season

Treatment	Bukavu			Tassa		
	Number of Fruits $Plant^{-1}$	Average Fruit Weight (kg)	Fruit Yield	Number of Fruits $Plant^{-1}$	Average Fruit Weight (kg)	Fruit Yield
Variety (V)						
Grey Bell	3.25	3.20	13.34	2.84	3.70	12.68
Kaolack	2.78	3.24	12.16	2.66	3.88	11.00
SE±	0.186	0.097	1.230	0.268	0.233	1.395
Salicylic Acid (SA)						
0	3.00	3.34	11.72	2.81	3.28	10.78
1.0	2.75	3.04	13.17	2.88	4.19	12.31
2.0	3.12	3.40	14.66	2.88	3.89	13.16
3.0	3.19	3.03	10.91	2.94	3.81	11.11
SE±	0.263	0.137	1.740	0.379	0.330	1.937
Interaction						
VxSA	Ns	ns	Ns	ns	Ns	ns

Means followed by the same letter(s) within treatment columns are not significantly different at 5% level of probability using DMRT

CONCLUSION

Hardening of water melon seeds with salicylic acid reduced days to emergence. This did not however, translates to increased vegetative growth and fruit yield in water melon. Vide these outcomes, hardening water melon seeds with salicylic acid is recommended for improved seedling emergence and good seedling/ stand establishment. Further research is also advocated on augmenting seed hardening with repeated foliar application of SA with a view to harness its potential for sustained production of water melon under rain-fed condition in the study areas.

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