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Full Length Review Article

INFLUENCE OF BIOZYME® ON CHLOROPHYLL CONTENT, FLOWERING AND PHYSIOLOGICAL MATURITY OF POTATO (*Solanum tuberosum* L.)CULTIVARS

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The study was conducted at Egerton University in 2010/2011 in a split plot experiment, arranged in a randomized complete block design. The research was replicated three times and repeated once. Main plots were assigned to potato cultivars (Tigoni and Asante), while subplots were assigned to Biozyme® foliar feed rates (0, 125, 250, 500 and 750 ml/ha). Each subplot was planted with 28 seed potato tubers spaced at 30 cm x 70 cm in four rows. A distance of 1 m separated adjacent subplots and main plots. During the growth period, data collected included chlorophyll content, flowering characteristics and days to potato physiological maturity which was subjected to analysis of variance and means separated using LSD at P=0.05. Biozyme® application increased the chlorophyll content and flowering characteristics but reduced the days to physiological maturity. The 750ml/ha Biozyme® foliar feed increased chlorophyll content by 19.45spads, number of flowers set by 21.86%and reduced the days to physiological maturity by 21 days as compared to the control rate (0 ml/ha). Increased chlorophyll content and better flowering exhibited by effects of Biozyme® are good characteristics as these parameters impact on poato growth and development that determine potato yield.

Key words: Potato, Biozyme®, chlorophyll, flowering, maturity

INTRODUCTION

Potato *(Solanum tuberosum* L.) is one of the most important food and cash crops in Kenya, and is second to maize in importance (Muthoni and Nyamongo, 2009). The area under production is 120,000 ha with an annual production of over 1 million tonnes (FAOSTAT, 2010). The Kenyan government has recognized the critical role potato plays in alleviating chronic hunger, against a background of declining production of other staple crops (African News Network, 2009). Most Kenyan growers are adopting potato production due its short growing season and tolerance to poor soils as compared to maize, which requires longer growing time and more fertile soils. To meet the increasing demand of potatoes, growers are now using different agrochemicals so as to improve on tuber yield, quality and maturity efficiency. Biozyme® foliar feed is widely used to hasten maturity of potato tubers. Biozyme® foliar feed is derived from the Norwegian seaweed (*Ascophylum nodosum*) through a special fermentation process (Anonymous, 2009). It stimulates plant growth by providing essential components (auxins, cytokinins, enzymes, hydrolysed proteins, betaines, and primary and secondary nutrients) at all critical stages. Synthetic plant growth regulators can be used to increase or retard plant height, prolong or break dormancy, prolong flower and plant life, abort flowers, promote rooting, branching and/or flowering (Malladi and Burns, 2007). Biozyme® stimulates crop growth at all critical stages through provision of hormonal and nutritional support, including cytokinins, auxins, enzyme-hydrolysed proteins, betaines, as well as primary and secondary nutrients. Due to the rising importance of potatoes in Kenya, there is need to establish the best agronomic practices to apply during production so that growers and consumers can reap maximum benefits. Growers applying Biozyme® biostimulant foliar feed on potato plants report reaping early and bigger tubers. This study determined the effects of Biozyme® foliar feed on chlorophyll content, flowering and physiological maturity of two potato cultivars popular in Kenya.

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MATERIALS AND METHODS

Field Experiment

An experiment was conducted on the Horticultural Research and Teaching farm at Egerton University, Njoro. The farm lies at 0°23' South, 35°35' East and 2238 meters above sea level. The farm normally receives 908 to 1012 mm rainfall per annum and 15.6°C to 23°C temperature. The soils on the farm are well-drained sandy loam-vintric mollic Andosols (Jaetzold and Schmidt, 1983). Grade II certified Asante and Tigoni seed potato tubers, measuring 45 to 65 mm in diameter, were obtained from the Agricultural Development Corporation Potato Project Centre in Molo, Kenya. Biozyme® foliar feed was bought from agrochemical shop.

Experiment Layout

The on-farm experiment was laid out in split-plots embedded in randomized complete block design, with 3 replications. The on-farm experiment was repeated once. The experimental field measured 50 m by 20.8 m. Each main plot measured 23.5 m by 7.6 m and was subdivided into sub-plots, measuring 5.6 m by 3.5 m each. A 1-m path separated adjacent main plots and subplots. Main plots were assigned to two potato cultivars Tigoni and Asante. Subplots were assigned to a control 0 ml/ha and four rates of Biozyme® foliar feed, namely: 125 ml/ha, 250 ml/ha, 500 ml/ha and 750 ml/ha. Tubers were planted at a spacing of 70 cm between rows and 30 cm within rows. Each experimental unit had 28 sprouted potato tubers in four rows. Data was taken on 10 inner plants with others acting as guard plants.

Land Preparation, Planting and Application of Treatments

Land preparation involved clearing of weeds followed by ploughing, harrowing and pulverizing of soil to at least 20 cm depth. Clods were broken to obtain fine, firm and weed-free surface for planting. Raised beds (20 cm from the ground level) were constructed in the fine soil before planting the tubers. Potato tubers were stored in a humid store with diffuse light to break dormancy and start sprouting before planting in the field. Dormancy was considered broken when sprouts, measuring 1.5 - 2.5 cm long were attained. Each rate of Biozyme® foliar feed was applied twice, at the 6th - 8th leaf stage and at flowering stage of potato plants, according to manufacturer's recommendation. A polythene sheet was erected between plots on the day of foliar-feeding to prevent drift to adjacent plots.

Routine Plant Management

All potato tubers were planted with 200 kg/ha (0.392 kg/subplot) DAP and 2.5 t/ha (4.9 kg/subplot) farmyard manure (Kabira, 2002), according to farmers' practice. They were foliar-fed with Biozyme® as previously described. Tubers were planted at a depth of 5 – 10 cm (Lung'aho *et al*., 2007) with dominant sprouts facing upwards for faster and uniform emergence. After establishment potato plants were weeded regularly up to 6 weeks after planting when they could suppress weeds. Ridging was done at two and four weeks after potato flowering to prevent greening of exposed tubers, infestation by potato tuber moths, and internal brown spot caused by high soil temperature (CIP, 2000). The final ridge size was 25 cm high (Lung'aho *et al*., 2007). Irrigation was done using drip tubes during early and late hours of the day to reduce evaporation. Plots were irrigated to maintain moisture content at field capacity, as potatoes are very sensitive to water stress after tuber initiation which coincides with when flowering commences (Gawroska *et al*., 1992; Thornton *et al*., 1996). Spraying was done to prevent late blight (*Phytophthora infestans*) using 3 kg/ha Ridomilin a manually-operated knapsack sprayer of 15-litre capacity. Spraying was repeated twice a week under wet conditions. Insecticides, Dimethoate and Alphacypermethrin, at 15 g/L and 100 g/L, respectively, were added to the fungicide whenever aphids, whiteflies, mites and other harmful insects were observed.

Data Collection

Chlorophyll content was measured using a SPAD chlorophyll meter (Minolta), from the second to the tenth week after emergence, at two weeks intervals. Days to flowering were recorded when 50% of the plants had started flowering. Number of flowers was counted per plot when 50% of the entire field had flowered. Days to physiological maturity was recorded when leaves of 70% of the plants in the plots turned yellow. Data collected was subjected to analysis of variance and where the F-test was significant (P<0.05), means were separated using the Least significant Difference (LSD) test. Regression analysis was done to establish relationships among variables.

RESULTS

Climatic Data

The distribution of moisture and temperature was different in the two potato growing seasons at Egerton University-Njoro. The total amount of rainfall received in season 1 (February-May, 2010) was 480 mm and in season 2 (July-October, 2010) was 618 mm. The average monthly maximum and minimum temperatures for seasons 1 and 2 were: 22.6 and 17.4°C and 21.2 and 16.6°C, respectively.

Effects of Biozyme® Rate on Chlorophyll Content of Potato Cultivars

The average chlorophyll content of potato cultivars tested increased with Biozyme® rates, the highest difference was observed between control and 500 ml/ha. There was an average of 28.8% chlorophyll content increase for 750 ml/ha compared to plots without Biozyme® foliar feed (Figure1). Among Biozyme® rates, there was no significant difference in chlorophyll content between 125 ml/ha and 250 ml/ha.

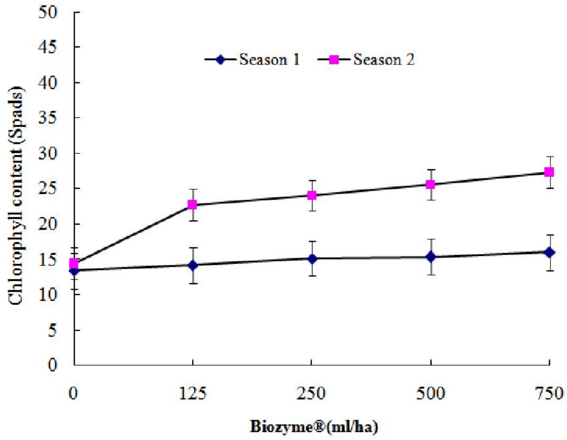

Figure 1: Influence of season and Biozyme® rate on chlorophyll content

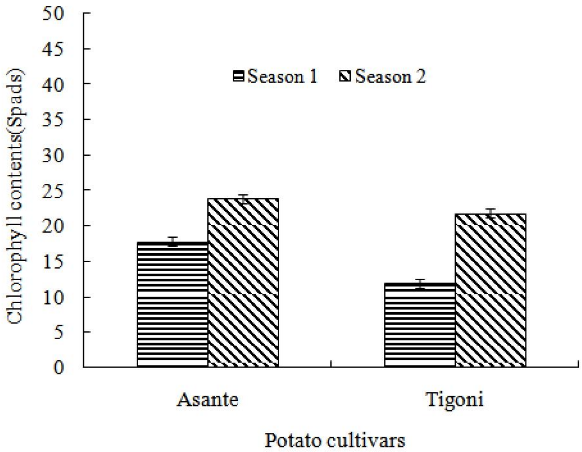

Figure 2: Response of chlorophyll content of potato cultivars to Biozyme® rate in seasons 1 and 2

Table 1: Effect of Biozyme® rate on chlorophyll content of potato cultivars in season 1

		Time (days after emergence)[a]		
Cultivar	Biozyme® (ml/ha)	28	42	56
Asante	0	15.67abc	17.10a	19.40ab
	125	15.90ab	15.27a	17.60abc
	250	15.97ab	17.30a	19.60ab
	500	16.40a	17.80a	20.10ab
	750	18.13a	19.50a	21.80a
Tigoni	0	7.80d	9.20a	11.50c
	125	11.3bcd	11.30a	15.00abc
	250	11.10bcd	12.30a	14.70abc
	500	10.83cd	12.37a	14.70abc
	750	11.07bcd	11.67a	14.10bc

[a]Means followed by the same letter(s) within a column are not significantly different at P < 0.05 by according to LSD

Table 2: Effect of Biozyme® rate on chlorophyll (Spads) content of potato cultivars in season 2

		Time (days after emergence)[a]		
Cultivar	Biozyme®	28	42	56
Asante	0	15.70a	17.07bc	15.37bc
	125	25.70a	27.10a	25.37a
	250	25.30a	26.70a	25.00a
	500	25.70a	27.20a	25.40a
	750	25.1oa	26.53a	24.80a
Tigoni	0	13.80a	11.20c	13.50c
	125	20.40a	17.8bc	20.10abc
	250	23.50a	20.7ab	23.20ab
	500	26.10a	23.5ab	25.80a
	750	30.20a	27.60a	29.80a

[a]Means followed by the same letter(s) within a column are not significantly different at P < 0.05 according to LSD

Asante had a higher amount of chlorophyll compared to Tigoni in both seasons (Figure 2). Although there was general increase in chlorophyll content with the increase of Biozyme® foliar feed rate, the increases were not significantly different (Tables 1 and 2).

Effects of Biozyme® Rate on Time to Flowering of Potato Cultivars

The time to flowering of potato cultivars depended on the amount of Biozyme® applied. Biozyme® at 750 ml/ha had the least time to flowering compared to control (21 and 19 days in seasons1 and 2, respectively) (Figure 3).

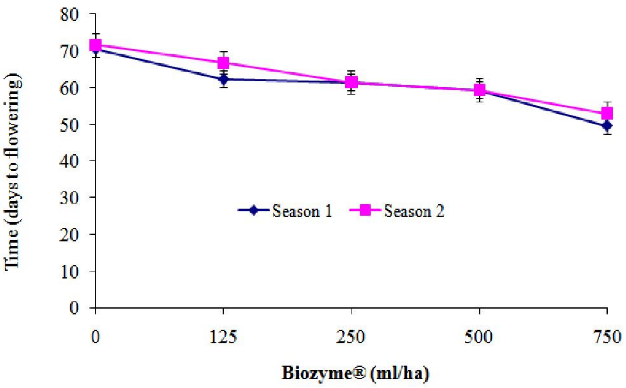

Figure 3: Effect of season and Biozyme® rate on flowering time of potato cultivars

There were no significant differences in average time to flowering among the two cultivars tested in both seasons (Figure 4). Interaction between cultivar and Biozyme® rate had inconsistent number of days to flowering in the two seasons. Nevertheless, Asante flowered 7 and 2 days earlier than Tigoni in seasons 1 and 2, respectively (Table 3).

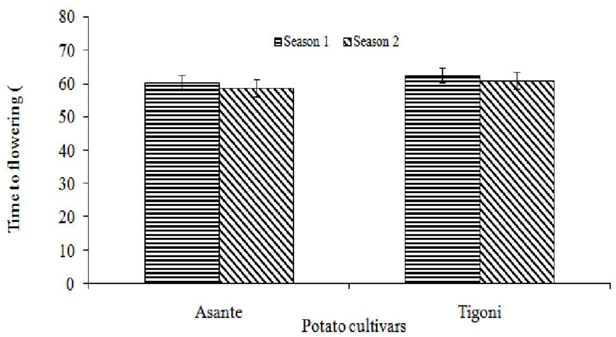

Figure 4: Flowering time response of potato cultivars to Biozyme® rate in seasons 1 and 2

Table 3: Effect of Biozyme® rate on flowering time of potato cultivars in seasons 1 and 2

		Biozyme® (ml/ha)[a]				
	Cultivar	0	125	250	500	750
Season 1	Asante	74.69a	58.28a	60.51b	58.41b	49.49c
	Tigoni	66.54a	66.28a	62.51a	60.1b	56.35c
Season 2	Asante	71.21a	69.23a	57.2b	57.29b	57.15b
	Tigoni	72.10a	64.41b	60.24b	59.92b	59.56b

[a]Means followed by the same letter(s) within a season are not significantly different at P< 0.05 according to LSD

Effects of Biozyme® Rate on Number of Flowers of Potato Cultivars

The number of flowers increased significantly with increase in Biozyme® foliar feed rate. The increase was an average of 29% for the two seasons compared to plots without Biozyme® foliar feed (Figure 5). Asante had more flowers across all Biozyme® rates in both seasons (Figure 6). The number of flowers of Asante cultivar was higher by 21% than that of Tigoni in both seasons. The number of flowers showed inconsistent change with the increase of Biozyme® rate. At the highest Biozyme® rate of 750 ml/ha, the number of flowers of these cultivars (Asante and Tigoni) were 34% and 56.71%, respectively, compared to those without Biozyme® foliar feed (Table 4).

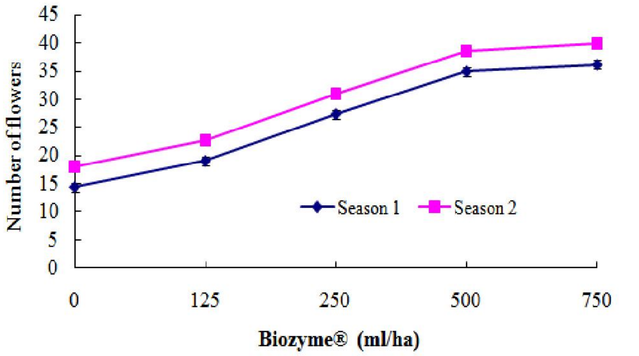

Figure 5: Effect of season and Biozyme® rate on number of flowers of potato cultivars

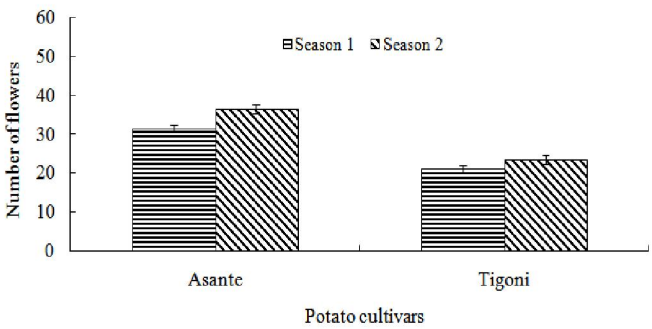

Figure 6: Response of number of flowers of potato cultivars when averaged across Biozyme® rates in seasons 1 and 2

Table 4: Effect of Biozyme® rate on flowers of potato cultivars in seasons 1 and 2

		Biozyme® (m/ha)[a]				
	Cultivar	0	125	250	500	750
Season 1	Asante	20.3c	25.7bc	29.33b	40.8a	41.97a
	Tigoni	8.4d	12.23d	25.33bc	29.03b	30.4b
Season 2	Asante	25.5d	30.87bcd	34.37b	45.8a	46.93a
	Tigoni	10.67e	14.67e	27.6cd	31.37bcd	33.03bc

[a]Means followed by the same letter(s) within a season are not significantly different at P < 0.05 according to LSD

Effects of Biozyme® Rate on Physiological Maturity of Potato Cultivars

The average days to physiological maturity were significantly influenced by rate of Biozyme® foliar feed applied. There was a decline in days to physiological maturity with the increase of Biozyme® foliar feed rate. When averaged across the two cultivars, potato plants treated with 750 ml/ha level of foliar feed matured earlier by 23 days and 18 days in the two seasons, respectively (Figure 7). Comparing the two tested cultivars, there was no significant difference between them in the two seasons (Figure 8). The Biozyme® foliar feed effect was not significant for Asante and Tigoni at 750ml/ha in the two seasons. However, Asante matured earlier than Tigoni by 1 day and 3 days in seasons 1 and 2, respectively (Table 5).

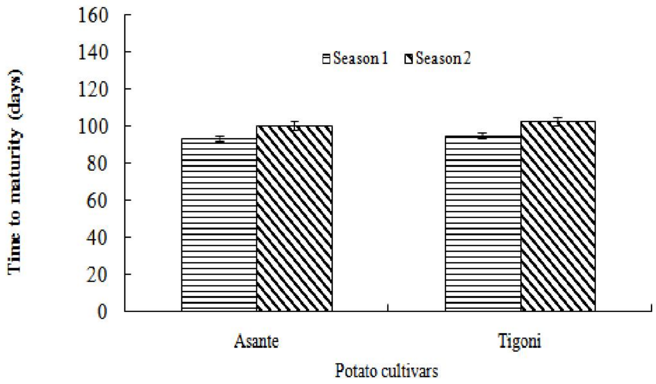

Figure 7: Influence of season on time to physiological maturity of potato cultivars treated with Biozyme® foliar feed

Table 5: Effect of Biozyme® rate on days to physiological maturity of potato cultivars in seasons 1 and 2

		Biozyme® (ml/ha)[a]				
	Cultivar	0	125	250	500	750
Season 1	Asante	107.12a	99.70abc	91.4abc	84.42bc	83.13c
	Tigoni	108.26a	100.2ab	92.27abc	89.57bc	84.32bc
Season 2	Asante	112.9ab	104.8ab	97.67ab	94.61ab	89.00b
	Tigoni	116.14a	108.7ab	100.4ab	93.42ab	92.13ab

[a]Means followed by the same letter(s) within each season are not significantly different at P < 0.05 according to LSD

DISCUSSION

Field Experimentation

Response of the various growth parameters measured depended on the season of potato production, cultivar of potato, and Biozyme® rate applied to the potato plants. The first season (February to May, 2010) which coincided with low rains proved most conducive for potato production since the tuber yields were higher than those of the second season (July to October, 2010) that coincided with a period of high rains. The temperature conditions were warmer in the first season than in the second season. Warmth drives more dry matter accumulation in plants than cold conditions. Holding all other factors constant, these two conditions (low rains and warm temperatures) could explain the higher tuber yields in season 1 compared to season 2. The increase in chlorophyll content in Biozyme® treated plants probably resulted in more photosynthesis as compared to control plants not treated with Biozyme®. There was a positive increase in chlorophyll content with increase in Biozyme® rate. In season 1, plants treated with the highest Biozyme® (750 ml/ha) had 16.2% more chlorophyll than control plants. This result was also similar in season 2 which had 47% more chlorophyll for plants treated with 750 ml/ha Biozyme® compared to control plants. Blunden *et al*. (1997) reported that application of Biozyme® on tomato soil or foliage produces leaves with higher chlorophyll content than untreated controls. This increase of chlorophyll content was probably as results of low chlorophyll degradation due to the presence of betaines in the Biozyme® foliar feed (Whaphan, 1993). Biozyme® has been shown to contain betaines such as gamma-aminobutyric acid betaine and glycine (Blunden *et al*., 1997) that increase chlorophyll in plants. Macronutrients have a great role in plant nutrition like nitrogen, potassium and phosphorous which are very essential for the growth and development of the plant (Attememe, 2009). This increase in total chlorophyll content in leaves might be due to Cytokinins and some nutrient materials in seaweed extracts that enter in the molecule structure of chlorophyll. (Al-Sahaff, 1989). Plots with Biozyme® application had early flowering, which coincides with tuberization in potato plants. From the 125 ml/ha Biozyme®, there were observable effects on days to flowering compared to control (0 ml/ha). Development of flower and the number of flowers produced are linked to the developmental stage of plants. The Biozyme® seaweed extract probably encouraged flowering by initiating robust plant growth, these findings are supported by Arthur *et al*. (2003), who reported that Biozyme® triggers early flowering and fruiting. In many crops, yield is associated with the number of flowers at maturity. Biozyme® application increased the number of flowers as compared to control potato plants that did not receive Biozyme® treatment. According to, this study Biozyme® treatment reduced time to physiological maturity significantly as compaired to control, 750ml/ha had the least maturity period. Early maturity is an important aspect in potato production for marketability and high prices, to escape off-season dry spells and cover in for short period between the long and short rainy seasons. Early maturing give assurance that food insecurity is at least tackled before the season's harvest acting as a coping strategy. Early maturity characteristics might be due to the Auxins in the seaweed extracts which have an effective rolein cell division and enlargement. This leads to increase the shoot growth, leaf area and plant dry weight (Gollan and Wright 2006). This might also be due to the minerals Zn, Cu and B in the seaweed extracts, which have a great role in cell division and enlargement and induce photosynthesis and then great shoot growth and early maturity (Lopez *et al.,* 2008).

Conclusion and Recommendation

Growth and development were enhanced by Biozyme® application. There was significant growth enhancement by the different rates of Biozyme®. This study provided useful information that revealed that Biozyme® can be used to hasten growth of potato plants.

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