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Enhancing productivity of sakurab (*Allium chinense* G. Don) using corn stalk mulch and suitable fertilizer type

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Abstract

Sakurab (*Allium chinense* G. Don) is a root vegetable and a traditional food seasoning of the Meranao people in the Philippines. This study determined the effects of corn stalk mulch and fertilizer treatment (no fertilizer, vermicast, 14-14-14, and combination of vermicast and 14-14-14) on the growth of two sakurab varieties (Rikit and Urder) and its economic profitability. Among the six parameters gathered, interaction effects were noted in plant survivability, vegetative yield, and bulb yield. Urder was significantly taller (37.31 cm) than Rikit (31.24 cm). The application of corn stalk mulch material caused a significant response in both varieties. Both varieties showed higher survivability when corn stalk mulch was used (81.58%) than when it was not used (24.25%). In both varieties, crops mulched with corn stalk had significantly higher vegetative and bulb yield than crops without mulch across all fertilizer treatments due to increase in the number of leaves (NOL). The increase in NOL was higher in Rikit compared to Urder variety. In both varieties, lowest vegetative yield was observed when neither fertilizer nor mulching was used (0.45 ton·ha^{-1} for Rikit and 0.83 ton·ha^{-1} for Urder). Using corn stalk mulch + vermicast fertilizer, both varieties produced higher vegetative and bulb yields (0.79 ton·ha^{-1} for Rikit and 1.17 ton·ha^{-1} for Urder). Results imply that better growth and yield of sakurab can be obtained by using corn stalk mulch and vermicast fertilizer which eventually produced the higher return on expense (ROE).

Introduction

Sakurab (*Allium chinense* G. Don) is a root vegetable and a traditional food seasoning of the Meranao people in the Philippines. In Meranao traditions, sakurab is also called "palapa", a spice blend with salt, chili and ginger, and is considered a complete setup for the Meranao food preparation (Santos, 2018), generally eaten raw as a side dish. It is also an important species in many parts of temperate and sub-tropical Asia, including China (where it is known as ch'iao t'ou), Japan (where it is known as rakkyo), the Philippines, Malaysia, Indonesia, Brunei, Vietnam and Thailand (Bah et al., 2012a; Mann & Stearn, 1960). Moreover, Chinese cuisine has been closely linked to spices of which sakurab is an important component. However, there is no written account that shows fixed distribution and adaptation of the crop. The plant is classified as 'least concern' in the IUCN Red List of Threatened Species (Fern, 2014).

Sakurab has grey-white bulbs and tiny leaves like those of chives (Mann & Stearn, 1960). It is inherently a temperature-sensitive crop in terms of bulb division and ultimate growth and development. It is ecologically adapted to the cool climate in Asia and to a certain extent in the sub-tropical climates in Southeast Asian countries (Wang et al., 2002). Growth and development require a temperature range of 15-25°C, depending on variety. In the Philippines, it is locally grown in elevated and sloppy areas of the towns of Balindong, Piagapo, Madalum and Calanogas (elevation between 700 and 900 meters (PhilAtlas, n.d.)) in Lanao del Sur. Informal interviews with local farmers revealed that sakurab is easily grown without the need for synthetic fertilizers. Indigenous and organic concoctions are enough like the use of organic mulches and organic manures, provided that the temperature is cool and the soil is loose. It is believed that sakurab is a low-input crop and compatible with chemical-free agriculture. Chemical-based crop production has been proven to be effective for increasing crop yield but food contamination and environmental pollutions are recognized as potential threats (Chaudhary et al., 2023). Further, the costs of chemicals are more often unbearable to common farmers. Now, there is a shift to organic farming (Ahmad, 2014), and modern agricultural systems are starting to prioritize food quality and agricultural sustainability (Zhang et al., 2019). Thus, sakurab's reputation as a low-input crop compatible with chemical-free agriculture makes it an important crop for further study.

Most of the Meranaos know sakurab only as a spice crop or a condiment but not its cultural requirements and its added values. The production of sakurab can be a potential source of farmer's income and contribute to the national economy. Hence, efforts towards sakurab industry development will benefit both the farmers and the country. Understanding sakurab, its nature or characteristics and its behavior in response to various production and management practices should be the first step in developing its production. Studies on sakurab typically involve its phytochemistry (Kuroda et al., 1995; Peng et al., 1996), in vitro propagation (Bah et al., 2012b; Yan et al., 2009), and the medicinal or nutritional effects of sakurab extracts (Lin et al., 2016; Xu et al., 2021). However, there is no study on factors that affects the growth of this crop in field condition. It is still not known whether mulching, which has been shown to be effective in other crops (Ghosh et al., 2020; Pramanick & Yadav, 2021) can enhance the growth and yield of sakurab. Such information is important to minimize cost of production and achieve the maximum production potential of the crop. Another aspect is the application of fertilizer which is necessary for combatting soil deterioration. In the case of sakurab growing, farmers observe different fertilization practices. There is a need to gather scientific evidence and know the comparative advantage of various fertilizer application practices.

Generally, the study was conducted to establish basic information on the production potential of sakurab in Lanao del Sur. Specifically, this study aimed to determine the effects of corn stalk mulch on the growth and yield of two sakurab varieties and to compare the performance of two sakurab varieties (Rikit and Urder) under various fertilization management practices, and to assess the economic profitability of the innovative production systems.

Methodology

Site Description

The field experiment was conducted at Saguiaran, Lanao del Sur, Philippines (8°00'38" N and 124°16'06" E, 625.5 masl) from March 26, 2020 to July 26, 2020. The experimental area falls under Type IV climate, characterized by evenly distributed rainfall throughout the year. The field is slightly sloping but takes 1-2 days to drain during heavy rains.

The average temperature during the duration of experiment was within the range of 21-34ºC, which was higher than the optimum range required by the growth and development of sakurab. The total monthly rainfall was about 130 mm in March when the field experiment started. By April, rainfall went down to 100 mm and gradually rose thereafter until its peak of 450 mm in July (Mindanao State University Philippine Atmospheric, Geophysical and Astronomical Services Administration (MSU PAGASA), n.d.).

Experimental Design and Treatments

An experiment was carried out in 2 × 2 × 4 split-split plot in a Randomized Complete Block Design (RCBD) with three replications. The treatments consisted of variety as the main plot, mulching as the subplot, and fertilizer type as the sub-subplot. Three equal blocks of 5.5 m × 5.5 m (30.25 m^2), each separated by a plot measuring 5.5 m × 0.5 m (2.75 m^2) for a total area of 5.5 m × 17.5 m (96.25 m^2), were set up to represent each replication. Each block was divided into two equal plots of 2.5 × 5.5 m (13.75 m^2) separated by a plot measuring 5.5 m × 0.5 m (2.75 m^2) to represent the main plot: Variety [V1 – Rikit (Small Variety) and V2 – Urder (Large Variety)]. Each main plot was sub-divided into two equal plots of 1.0 m × 5.5 m (5.5 m^2), also separated by a plot measuring 5.5

m × 0.5 m (2.75 m^2), to represent the sub-plot: Mulching [M1 – No Mulch and M2 – Organic Mulch]. The distance between plots was 0.5 m. Each subplot was further sub-divided into 4 equal plots of 1 × 1 m (1 m^2) each to represent sub-sub plot: Fertilizer [F1 – control (no fertilizer), F2 – organic fertilizer (30 ton·ha^{-1} of Vermicast), F3 – inorganic fertilizer (880 kg·ha^{-1} of 14-14-14) and F4 – organic and inorganic fertilizer combination]. The 48 sub-sub plots were prepared and subjected to different treatment combinations.

Preparation of Plots

Cultural management practices were observed in the preparation of the planting area. The area was prepared by alternate plowing and harrowing until good soil tilt was achieved. The experimental plots were then laid out using spade and rake. Each plot measuring 1 × 1 m (1 m^2) was enclosed with a wooden box to maintain the raised bed and prevent possible soil erosion during heavy rains. Moreover, the 24 plots under the organic mulch condition were applied with corn stalk mulch at 5 cm thick one week before planting.

Bunches of Rikit (small variety) and Urder (large variety) of sakurab from Piagapo, Lanao del Sur were used in this experiment. To prepare the planting materials, the roots were cut close to the bulb and the leaves were snipped to about 15-20 cm from the base of the bulb. Each bulb was then separated from the cluster to serve as one planting seed piece.

A single bulb was directly planted into a hole made by using Buso (digging bar) at a depth of 5 cm. The planting distance between hills is 10 cm, so that each 1 m^2 sub-plot contained 100 plants.

Vermicast produced by Hijra Organic Farm at Saguiaran, Lanao del Sur, Philippines was used as organic fertilizer for the sakurab. The organic fertilizer material was applied based on the prescribed treatment rate (3 kg per plot). It was incorporated into the topsoil layer during the leveling of the experimental plots prior to the application of the mulch. Inorganic fertilizer (14-14-14) was applied one week after planting, in accordance with the prescribed rate for bulb and green onions (385-860 kg per hectare, or 60 grams per plot) (Bautista & Mabesa, 1978).

Plants were irrigated using a water sprinkler, and was done right after planting the bulbs. A total of four gallons of water was applied per plot every day in the morning for one week. Except during rainy days, succeeding watering was done at three-day intervals up to the end of the experiment. To keep the experimental area clean, the pathway in between blocks and plots were maintained to be weed-free. Weeds that grew in the experimental plots were pulled or rogued by hand-pulling every two weeks, to prevent competition for nutrients, water, carbon dioxide, space, and sunlight. The crops were harvested four months after planting by gently loosening the surrounding soil using spade to carefully pull them up.

Data Gathered

All crops were harvested on the same day, four months after planting, and this was done by gently loosening the surrounding soil using spade to carefully pull them up. Survivability was recorded by getting the proportion of plants that survived per plot multiplied by 100.

Ten plants from the inner portion of the experimental plot were randomly selected. Based on the randomly selected plants, plant height, number of leaves, bulb yield, and number of bulbs per hill were determined. Plant height was the length from the soil up to the tip of the leaves. Bulb yield was the weight (in grams per hill) of the bulbs after removing the leaves, leaving only the edible parts. Vegetative yield was the weight of the leaves. Vegetative yield was converted to ton ha^{-1} using the formulas below:

$$\text{Vegetable yield (ton·ha}^{-1}) = \text{Vegetable yield per plot (kg·m}^{-2}) \times \frac{\mathbf{1}\ \text{ton}}{\mathbf{1000\ kg}} \times \frac{\mathbf{10000\ m^2}}{\mathbf{1\ ha}}$$

Statistical Analysis

All parameters gathered were averaged across all samples in each condition. Analysis was performed using Analysis of Variance (ANOVA) in Split-split Plot Design with three replications to determine significant differences among treatment combinations. Comparison among means for significantly different parameters was done using Least Significant Difference (LSD) tests. The Statistical Tool for Agricultural Research (STAR) program was used for ANOVA and comparisons of treatment means.

Results

Table 1 shows the summary of analysis of variance of the three factors and their interactions on the growth parameters of sakurab. Three-way interaction among the factors were found in survivability, vegetative yield, and bulb yield while two-way interaction between at least two factors were found in all parameters except plant height. To elucidate the interactions, the means of growth parameters for each factor are shown in Table 2 (for comparison of mulching condition and variety), Table 3 (for comparison of fertilizers).

Table 1. Summary of analysis of variance of the three factors and their interactions on growth parameters of sakurab.

	Parameters					
Factor	Plant height (cm)	Survivability (%)	Vegetative yield (ton·ha^{-1})	Bulb yield (g per hill)	Number of leaves	Number of bulbs
Variety	**	*	**	ns	ns	ns
Mulching	**	**	**	**	**	ns
Fertilizer	ns	**	**	**	**	ns
Variety × Mulching	ns	*	**	*	**	**
Variety × Fertilizer	ns	ns	**	*	ns	ns
Mulching × Fertilizer	ns	ns	**	**	**	ns
Variety × Mulching × Fertilizer	ns	**	**	*	ns	ns

ns – non significant, ** - highly significant, *significant (LSD test of significance)

Table 2. Comparison of variety and mulch condition on growth parameters at harvest of sakurab for each fertilizer condition, Saguiaran, Lanao del Sur, Philippines, 2020.

	No fertilizer		Vermicast		14-14-14		Combination of vermicast and 14-14-14		Mean		Grand mean
	Rikit	Urder	Rikit	Urder	Rikit	Urder	Rikit	Urder	Rikit	Urder	
Plant height											
Without mulch	19.88	24.74	25.28	25.29	20.28	25.79	22.45	26.01	21.97	25.46	23.72^{b}
With mulch	41.35	44.10	40.62	50.77	39.64	51.70	40.45	50.05	40.52	49.16	44.84^{a}
Survivability											
Without mulch	17.33^{b,B}	29.67^{a,A}	25.33^{b,A}	29.33^{b,A}	9.67^{b,B}	31.33^{b,A}	22.67^{b,A}	28.67^{b,A}	18.75	29.75	24.25
With mulch	79.00^{a,A}	75.67^{a,A}	82.33^{a,A}	92.67^{a,A}	78.00^{a,A}	78.33^{a,A}	82.67^{a,A}	84.00^{a,A}	80.50	82.67	81.58
Vegetative yield											
Without mulch	0.45^{b,A}	0.83^{b,A}	0.79^{b,A}	1.17^{b,A}	0.24^{b,A}	1.02^{b,A}	0.51^{b,A}	1.15^{b,A}	0.50	1.04	0.77
With mulch	5.47^{a,B}	8.80^{a,A}	6.55^{a,B}	13.62^{a,A}	6.03^{a,B}	10.44^{a,A}	6.51^{a,B}	11.45^{a,A}	6.14	11.80	8.61
Bulb yield											
Without mulch	1.43^{b,A}	2.03^{b,A}	1.80^{b,A}	1.93^{b,A}	0.80^{b,A}	1.63^{b,A}	1.50^{b,A}	1.80^{b,A}	1.38	1.85	1.62
With mulch	5.90^{a,A}	5.53^{a,A}	9.07^{a,B}	14.13^{a,A}	8.70^{a,B}	12.70^{a,A}	8.60^{a,B}	12.10^{a,A}	8.07	11.12	9.59
Number of leaves											
Without mulch	3.43	4.13	3.77	4.87	2.67	4.33	3.30	4.13	3.29^{b}	4.37^{b}	3.83
With mulch	8.60	5.93	10.27	9.37	10.17	10.70	10.77	8.23	9.95^{a}	8.56^{a}	9.26
Number of bulbs											
Without mulch	2.47	2.83	2.70	3.27	2.27	2.87	2.27	2.83	2.43^{b,A}	2.95^{a,A}	2.69
With mulch	3.77	1.70	3.87	2.00	3.93	2.07	3.83	2.03	3.85^{a,A}	1.95^{b,B}	2.90

Note: For each growth parameter, different superscript small letters indicate statistically significant differences between mulch conditions (i.e., vertically between two rows) while different superscript capital letters indicate statistically significant differences between varieties (i.e., horizontally between two columns).

Table 3. Comparison of fertilizer condition on growth parameters at harvest of sakurab across variety and mulching condition, Saguiaran, Lanao del Sur, Philippines, 2020.

		Rikit		Urder		Mean		
		Without mulch	With mulch	Without mulch	With mulch	Without mulch	With mulch	Grand Mean
Plant height	No fertilizer	19.88	41.35	24.74	44.10	22.31	42.73	35.52
	Vermicast	25.28	40.62	25.29	50.77	25.29	45.70	35.49
	14-14-14	20.28	39.64	25.79	51.70	23.04	45.67	34.35
	Vermicast + 14-14-14	22.45	40.45	26.01	50.05	24.23	45.25	34.74
Surviva-bility	No fertilizer	17.33^{ab}	79.00^{a}	29.67^{a}	75.67^{c}	23.50	77.34	50.42
	Vermicast	25.33^{ab}	82.33^{a}	29.33^{a}	92.67^{a}	27.33	87.50	57.42
	14-14-14	9.67^{b}	78.00^{a}	31.33^{a}	78.33^{bc}	20.50	78.17	49.33
	Vermicast + 14-14-14	22.67^{a}	82.67^{a}	28.67^{a}	84.00^{bc}	25.67	83.34	54.50
Vegetative yield	No fertilizer	0.45^{a}	5.47^{b}	0.83^{a}	8.80^{d}	0.64	7.14	3.89
	Vermicast	0.79^{a}	6.55^{a}	1.17^{a}	13.62^{a}	0.98	10.09	5.53
	14-14-14	0.24^{a}	6.03^{ab}	1.02^{a}	10.44^{b}	0.63	8.24	4.43
	Vermicast + 14-14-14	0.51^{a}	6.51^{a}	1.15^{a}	11.45^{c}	0.83	8.98	4.91
Bulb yield	No fertilizer	1.43^{a}	5.90^{b}	2.03^{a}	5.53^{c}	1.73	5.72	3.72
	Vermicast	1.80^{a}	9.07^{a}	1.93^{a}	14.13^{a}	1.87	11.60	6.73
	14-14-14	0.80^{a}	8.70^{a}	1.63^{a}	12.70^{ab}	1.22	10.70	5.96
	Vermicast + 14-14-14	1.50^{a}	8.60^{a}	1.80^{a}	12.10^{b}	1.65	10.35	6.00
Number of leaves	No fertilizer	3.43	8.60	4.13	5.93	$3.78^{a,B}$	$7.27^{b,A}$	5.52
	Vermicast	3.77	10.27	4.87	9.37	$4.32^{a,B}$	$9.82^{a,A}$	7.07
	14-14-14	2.67	10.17	4.33	10.70	$3.50^{a,B}$	$10.43^{a,A}$	6.97
	Vermicast + 14-14-14	3.30	10.77	4.13	8.23	$3.72^{a,B}$	$9.50^{a,A}$	6.61
Number of bulbs	No fertilizer	2.47	3.77	2.83	1.70	2.65	2.74	2.69
	Vermicast	2.70	3.87	3.27	2.00	2.99	2.94	2.96
	14-14-14	2.27	3.93	2.87	2.07	2.57	3.00	2.79
	Vermicast + 14-14-14	2.27	3.83	2.83	2.03	2.55	2.93	2.74

Note: For each growth parameter, different superscript small letters indicate statistically significant differences between fertilizer conditions (i.e., vertically between two rows) while different superscript capital letters indicate statistically significant differences between mulch conditions (i.e., horizontally between two columns).

Plant Height

Interactions of independent factors did not significantly affect the plant height of sakurab. However, both variety and mulch condition significantly influenced plant height. Urder was significantly taller (37.31 cm) compared to Rikit (31.24 cm). Moreover, plants grown with corn stalk mulch were significantly taller (44.84 cm), in contrast to plants without mulch (23.72 cm). The plant heights across the two mulch conditions can also be seen in Figures 1 and 2.

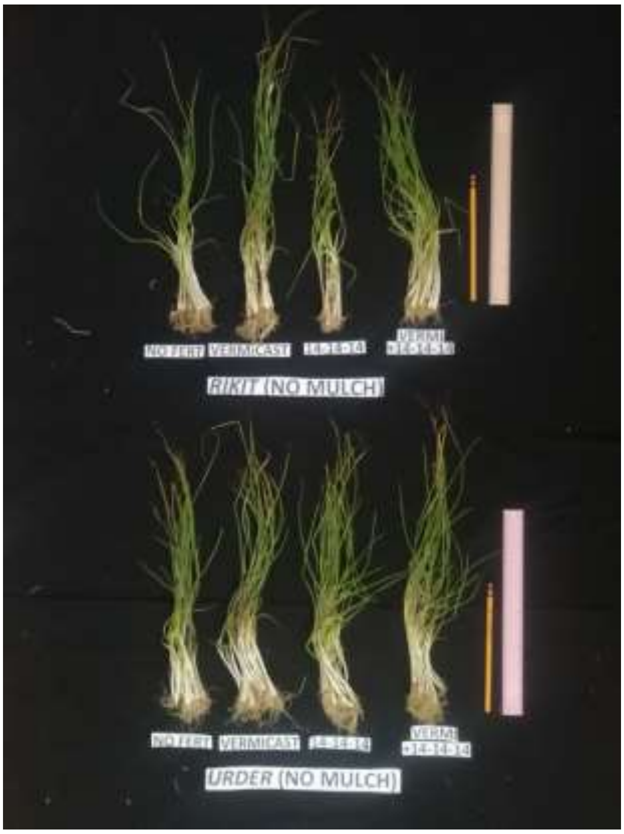

Figure 1. Harvested bunches of Rikit and Urder varities of sakurab grown without mulch at different kinds of fertilizer application (10hills/plot).

Survivability

Lower survivability was observed in both varieties without mulch (grand mean: 24.25% without mulch and 81.58% with mulch in Table 2). Rikit had significantly lower survivability than Urder in the "no mulch" condition when no fertilizer (17.33 % versus 29.67%) or 14-14-14 was used (9.67% versus 31.33%). Further, the effect of fertilizers varied between varieties (Table 3). Fertilizer application affected the survivability of Rikit only when mulch was not applied. However, the opposite was observed in Urder as fertilizer application affected survivability only when mulch was applied. In Rikit, without mulching, survivability is comparable on treatments no fertilizer (17.33%), organic fertilizer alone (25.33%) and combination of organic and inorganic fertilizer (22.67%). However, the application of 14-14-14 alone led to significantly lower survivability (9.67%). In Urder, under corn stalk mulch, survivability in plots fertilized with vermicast alone (92.67%) was significantly higher than unfertilized plants (75.67%) and those fertilized with inorganic fertilizer (78.33%) or a combination of vermicast and inorganic fertilizer (84.00%).

Figure 2. Harvested bunches of Rikit and Urder varities of sakurab grown with stalk mulch at different kinds of fertilizer application (10 hills/plot).

Vegetative Yield and Bulb Yield

Similar results for vegetative yield and bulb yield were observed. In both Rikit and Urder, crops with mulch had significantly higher vegetative yield and bulb yield compared to those with no mulch across all fertilizer treatments, with significant differences higher in Urder than in Rikit (Table 2). Further, fertilizer application resulted in significant differences in vegetative yield and bulb yield in both varieties but only under mulching condition. In terms of vegetative yield, Rikit applied with organic (6.55 ton·ha^{-1}) or a combination of inorganic and organic fertilizer (6.51 ton·ha^{-1}) resulted in significantly higher vegetative yield than crops without any fertilizer (5.47 ton·ha^{-1}). In the case of Urder, the vegetative yield was significantly different across fertilizer treatments, and highest on crops applied with organic fertilizer (13.62 ton·ha^{-1}), followed by those applied with a combination of inorganic and organic fertilizers (11.45 ton·ha^{-1}), inorganic fertilizer (10.44 ton·ha^{-1}), and no fertilizer (8.8 ton·ha^{-1}).

In terms of bulb yield in the “mulch” condition, Rikit applied with organic (9.07 grams/hill), inorganic fertilizer (8.70 grams/hill) or a combination of inorganic and organic fertilizer (8.60

grams/hill) resulted in significantly higher bulb yield than crops with no fertilizer (5.90 grams/hill). Urder applied with organic fertilizer resulted in significantly higher bulb yield (14.13 grams/hill) than crops applied with a combination of inorganic and organic fertilizers (12.70 grams/hill) or no fertilizer (5.53 grams/hill).

Number of Leaves per Hill

The number of leaves of sakurab was significantly affected by mulching and fertilizer as independent factors, interactions of variety and mulching and the interactions of mulching and fertilizer (Table 1).

There was significant interaction of variety and mulching on the number of leaves per hill. In both varieties, mulching led to an increase in the number of leaves. However, the increase was higher for variety Rikit (3.29 leaves per hill without mulching to 9.95 leaves per hill with mulching) compared to variety Urder (4.37 leaves per hill without mulching to 8.56 leaves per hill with mulching).

There was also significant interaction of mulching and fertilizer on the number of leaves per hill. In the no mulch condition, there were minimal differences in leaf counts whether fertilizers were applied or not. However, under corn stalk mulch condition, all kinds of fertilizers in this study resulted in more leaves than when no fertilizer was used. The application of fertilizer, regardless of kind, was effective in increasing the number of leaves under corn stalk mulch (7.27 leaves for unfertilized plants versus 9.82, 10.43, and 9.50 leaves per hill for plants fertilized with vermicast alone, 14-14-14 alone, and a combination of vermicast and 14-14-14, respectively).

Number of Bulbs

The only significant interaction was in the variety-mulching pair, and there were no significant main effects (Table 1). This is because of the crossover effect (Table 2); that is, Rikit has significantly more bulbs when applied with mulch (3.85) than when mulch was not applied (2.43). By contrast, Urder produced significantly more bulbs without mulch application (2.95) compared to with mulch (1.95).

Return on Expense (ROE)

Tables 4 and 5 show the return on expense (ROE) for Urder and Rikit varieties, respectively. Urder variety grown with corn stalk mulch and vermicast fertilizer demonstrated the highest vegetative yield of 13.62 ton·ha^{-1} (Table 2) and highest ROE. Given a conservative farm gate price of fresh market sakurab at Php 100.00 per kg, the prospective net income per hectare is Php 767,000 with 128.9% return on expense (Table 4). The ROE for the Rikit variety was much lower, where the highest ROE (23.5%) was attained in the mulch and no fertilizer condition (Table 5). In both varieties, planting sakurab without mulch led to net loss.

Discussion

Mulching and fertilizers have significant impacts on the soil conditions and fertility which explains the varied responses of plants subjected to different treatments. Mulching produced higher results across all growth parameters investigated in this study in all fertilizer conditions and in both varieties (except for the number of bulbs of Urder). The overall influence of mulch on the growth and development of sakurab is highly desirable, particularly because it helps in the conservation of soil moisture which is an important factor in growing Allium crops (Bah et al., 2012b; Woldetsadik, 2003). Allium crops are shallow-rooted and require frequent irrigation because they extract very little water from the soil. Results from this study imply that bulb length was associated with bulb yield. Longer bulbs which were observed from plants with mulching materials and fertilizers were heavier in bulb weight. Thus, the top soil must be kept moist to stimulate root growth and promote adequate water for the crops. Mulching decreases the loss of soil water through evaporation and conserves soil moisture, leading to a reduction in irrigation requirements, an increase in root development, promotion of faster crop development and earlier crop harvest, and a reduction in weed attack, favoring the overall growth and development of plants, more particularly the roots (Mahajan et al., 2007). It is a technology that suppresses weed growth and reduces the frequency of irrigation. It was observed during the early stages of the field experiment when under unfavorable warm and dry conditions, plants without mulch withered and died back.

Table 4. Return on expense for one hectare sakurab production (Urder variety).

			Fixed expenses			Fertilizer expenses			Mulching expenses				
	Yield (kg)	Income (PhP, based on PhP100 farm gate price)	Labor–plowing/ harrowing	Labor-planting, harvesting, grading/ bunding	Planting materials	Labor-application of fertilizer	14-14-14	Vermicast	Labor-collection of mulch	Labor-piling of mulch	Total expenses	Net income	ROE
No mulch													
No fertilizer	830	83000	10000	18000	400000						428,000	-345,000	-80.6%
With vermicast	1170	117000	10000	18000	400000	2000		150000			580,000	-463,000	-79.8%
With 14-14-14	1020	102000	10000	18000	400000	2000	44000				474,000	-372,000	-78.5%
With vermicast + 14-14-14	1150	115000	10000	18000	400000	2000	44000	150000			624,000	-509,000	-81.6%
With mulch													
No fertilizer	8800	880000	10000	18000	400000				9000	6000	443,000	437,000	98.6%
With vermicast	13620	1362000	10000	18000	400000	2000		150000	9000	6000	595,000	767,000	128.9%
With 14-14-14	10440	1044000	10000	18000	400000	2000	44000		9000	6000	489,000	555,000	113.5%
With vermicast + 14-14-14	11450	1145000	10000	18000	400000	2000	44000	150000	9000	6000	639,000	506,000	79.2%

Table 5. Return on expense for one hectare sakurab production (Rikit variety).

			Fixed expenses			Fertilizer expenses			Mulching expenses				
	Yield (kg)	Income (PhP, based on PhP100 farm gate price)	Labor–plowing/ harrowing	Labor-planting, harvesting, grading/ bunding	Planting materials	Labor-application of fertilizer	14-14-14	Organic fertilizer	Labor-collection of mulch	Labor-piling of mulch	Total expenses	Net income	ROE
No mulch													
No fertilizer	450	45000	10000	18000	40000						428,000	-383,000	-89.5%
With vermicast	790	79000	10000	18000	40000	2000		150000			580,000	-501,000	-86.4%
With 14-14-14	240	24000	10000	18000	40000	2000	44000				474,000	-450,000	-94.9%
With vermicast + 14-14-14	510	51000	10000	18000	40000	2000	44000	150000			624,000	-573,000	-91.8%
With mulch													
No fertilizer	5470	547000	10000	18000	40000				9000	6000	443,000	104,000	23.5%
With vermicast	6550	655000	10000	18000	40000	2000		150000	9000	6000	595,000	60,000	10.1%
With 14-14-14	6030	603000	10000	18000	40000	2000	44000		9000	6000	489,000	114,000	23.3%
With vermicast + 14-14-14	6510	651000	10000	18000	40000	2000	44000	150000	9000	6000	639,000	12,000	1.88%

The implication is that constraints brought about by high soil evaporation and temperature can be altered through mulching practice. According to Singh and Singh (2018), application of crop residue mulch improved the yield of onion by 17%. Their study emphasized that mulching with crop residues enhanced crop yield and economized water by providing hydrothermal conditions in semi-arid subtropical irrigated regions. A similar study by Barakat et al. (2019) showed that rice straw mulch had pronounced effect on morphological characters and bulb yield of garlic and its components compared to bare soil. The effect of rice straw mulch on the growth and yield of garlic was due to the decreased infiltration rate, cost-efficiency in reduction of nutrient leaching, regulation of soil temperature, conservation of soil moisture, stimulated soil flora activity, reduced weed growth, addition of organic matter to soil and enhanced adequate micro atmosphere surrounding plants (Bhardwaj & Kendra, 2013; Ghosh et al., 2006).

In this study, the impact of inorganic fertilizer on soil temperatures and soil moisture utilization created a more adverse effect on plant withering as the fertilizer competed for the scarce moisture in the soil. Under conditions of warm and dry weather in a relatively deteriorated soil, vermicast preserves soil moisture, while 14-14-14 can aggravate plant water stress and plant withering.

By contrast, organic fertilizer resulted in significantly higher survivability and yield, especially in the mulch condition. The quality of soil is directly or indirectly influenced by nitrogen nutrition and mulching. Mulch improves soil conditions by increasing the level of carbon and nitrogen in the soil, an indication of improved soil fertility (Duda et al., 2003), reducing loss of nutrients and moisture, and enhancing the biological activities in the soil (Acharya et al., 2005). Combining the application of nitrogenous fertilizers and mulches is a way of improving soil fertility. The combination of nitrogen fertilizer and mulching was also found with very similar advantages by Pinamonti (1998). Singh et al. (2011) revealed that the application of organic fertilizer and decomposition of organic mulch leads to an improvement in physical, chemical and biological properties of soil and an increase in the water-holding capacity due to the additional amount of humus in soil. Further, decomposition of organic materials release acids that acidify an alkaline soil, making Fe, Zn, Mn and Cu more available to plants. Akhtar et al. (2019) stated that the integrated use of organic mulch with nitrogen fertilizer improves soil functionality and increases the amount of phosphorus and potassium in the soil, resulting in an increase in net mineralization of soil organic nitrogen.

The study also revealed some genetic factors affecting growth parameters of sakurab. The significantly higher plant height of Urder variety can be attributed to genetic properties. Further, variations in number of bulbs are caused by genetic factor. Bulb division in Rikit is inherently faster than that in Urder, which is why this variety produced significantly more bulbs. However, genetic-based potentials can be modified by environmental factors (Pava & Abellanosa, 1987). The extent of gene expression for plant height and number of bulbs is dictated by the kind of stimuli encountered in the field.

Conclusion

Corn stalk mulch contributed significantly to the improvement in plant height of both varieties of sakurab. Plants grown with corn stalk mulch were significantly taller than those grown without mulch. Application of fertilizer regardless of kind was effective in increasing the number of leaves under corn stalk mulch. There was also no distinction among vermicast, 14-14-14 fertilizer, and combination of 14-14-14 and verimicast on plant height and number of bulbs whether mulch was applied or not. Fertilizer application did not improve vegetative yield per hectare of both varieties when there was no mulching. However, application of corn stalk mulching material caused a significant response to fertilizer application in terms of survivability, vegetative yield, and bulb weight for Urder. The long dry and warm weather rendered vermicast superior to 14-14-14 or 14-14-14 + vermicast in terms of soil moisture and temperature factors that enhance plant survivability. Results imply that better growth and yield of sakurab can be achieved using corn stalk mulch and vermicast fertilizer, with the highest ROE observed in Urder variety grown with corn stalk mulch and vermicast fertilizer.

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No potential conflict of interest was declared by the authors.

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