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# Growth and yield performance and viral disease screening of Philippine native garlic varieties grown in Bacnotan, La Union, Philippines

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**Key words:** Allexivirus, Bulb, Bulbil, Garlic virus, OYDV, Variety

**Abstract**

The Philippines has been consistently importing most of its domestic garlic demands over the past years. This was due to low local garlic production. The major problem is the low-quality planting materials resulting in low yield per unit area and the speculated viral diseases infected the garlic plants. Hence, the study was conducted to determine the performance of the Philippines' native garlic varieties in Bacnotan, province of La Union. Specifically, the study aimed to determine the survival rate (%), weight of bulb (g), diameter of bulb (cm), bulb yield (kg) per hectare, bulbil per plant, weight of bulbil (g), bulbil yield (kg) per hectare and identify the virus diseases present in the native garlic varieties. The varieties tested were Ilocos Pink (V1), Romblon (V2), Tan Bolters (V3), Miracle (V4), Ilocos White (V5), Mexican (V6), and Batanes Red (V7). The result showed that Ilocos Pink and Mexican varieties comparably produced the highest survival rate (%) and bulb yield per hectare (kg). Batanes Red variety produced the most bulbil per plant, heaviest bulbil (g), and highest bulbil yield per hectare (kg). Meanwhile, bulbil samples subjected to virus screening tested positive for Allexivirus and Onion Yellow Dwarf Virus (OYDV). The result suggests that farmers in Bacnotan, La Union, Philippines can use Ilocos Pink and Mexican varieties for higher garlic bulb production while Batanes Red for higher bulbil production. However, studies to improve the survival rate and minimize the disease infection should be conducted to improve the quality and quantity of bulb and bulbil production of the native garlic varieties.

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**Introduction**

Garlic (*Allium Sativum* L.) or locally known as "bawang" in the Philippines is a perennial herb of the Amaryllidaceae family (Moren *et al.*, 2016; Trinklein, 2015). It was proposed to evolve from wild *Allium longicuspis* in Central Asia, about 5,000–6,000 years ago (Chepkemoi, 2017; Hirst, 2019; Jing, 2020). It is mostly grown annually for its bulb (Mahr, 2023) with many uses in culinary and medicine (Bacelar *et al.*, 2023; Lidiková *et al.*, 2023). It is indispensable to everyone's kitchen because it can be used daily from preparing dishes such as fried rice, delicious main dishes, side dishes, and snacks to processing of value–added products such as garlic powder, paste, chips, and grits due to its unique pungent flavor (Alfaro, 2023). Aside from just food, garlic is also used as medicine (Ayaz & Alpsoy, 2007). Clinically, consuming garlic could lower blood pressure, cholesterol, and glucose concentration, as well as prevent arteriosclerosis and cancer (Assimiti, 2022). Epidemiologically, it inversely correlates with the risk of oral, stomach, esophageal, colon, and prostate cancer (Tsai *et al.*, 2012). Moreover, this crop poses various biological activities including antibacterial, antithrombotic, antioxidant, immunomodulatory, and antidiabetic actions and modulation of drug metabolism (Shang *et al.*, 2019). That is why garlic stands as the second most important allium crop (Jiku *et al.*, 2020) and the most utilized supplement (Bongiorno *et al.*, 2008). China is the leading producer of garlic accounting for 20.0 million tons followed by India with 1.25 million tons per year. The other three top-producing countries of garlic include; South Korea, Egypt, and Russia producing 0.35, 0.26, and 0.26 million tons, respectively (Chepkemoi, 2017).

In the Philippines, garlic is considered a good cash crop with high investment returns (Lopez & Anit, 1994). A hectare of garlic production costs P148,586.50 and could produce a 4,000kg bulb yield. The 4 tons yield, if sold for P80.00/kg will give a net income of P91,413.50 equivalent to 61.52% return on investment (ROI) (Department of Agriculture - Regional Field Office No. 02, 2012). However, if sold at the current local retail price of P170.00, garlic will provide a higher net income of approximately P360,000.00 per hectare (SunStar / DAVAO, 2020). Ilocos Region tops garlic production in the country with approximately 5.10 thousand metric tons or 60% to 65.8% share in the total domestic production (Billedo & Paller, 2020; Philippine Statistics Authority, 2018). Ilocos Norte has devoted 1,880 hectares, 130 hectares in Ilocos Sur and four hectares in Pangasinan while La Union has no land devoted to commercial garlic production (Micua, 2017). However, the production of garlic and the area harvested is decreasing (Lubang, 2018; Philippine Statistics Authority, 2019). More than 90% of the Philippines' garlic supply in the market is imported (Department of Agrarian Reform, 2017). The constraints include the low yield potential of existing garlic varieties and the absence of quality planting materials among others (Department of Agrarian Reform, 2017; Lubang, 2018). Local garlic farmers in the Philippines produce a very low yield at 3 tons per hectare versus 27 tons per hectare in China (Dy, 2018). Garlic produced locally is also more expensive than imported ones (Mangaluz, 2023). Garlic in the country is commonly propagated through its cloves and the planting materials that are circulating have been used for so long already and have shown to have disease infection which may cause a significant reduction in yield (Guiam, 2022).

There are strategies developed to boost the quantity and quality of garlic produced in the country. One of these strategies is to produce disease-free planting materials. However, plant diseases should be properly identified and detected. The result can help produce disease-free planting materials for farmers and can also be used as an effective decision-making tool for the prevention of the spread and occurrence of plant diseases in the field. This can potentially increase the quality and quantity of produce, in turn, can alleviate importation (superadmin, 2020). The yield and performance of the plant can be greatly impacted by plant diseases like viruses (R. *et al.*, 2014). Hence, to develop strategies to prevent and control the spread of the disease, adequate identification is therefore required. On the other hand, a small bulb that is developed in the scape of a garlic plant known as bulbils can be used for micropropagation and virus

elimination (Boken *et al.*, 2017; Ebi *et al.*, 2000). Garlic bulbil can be used as planting material because it can thwart the transmission of viruses and soil-borne diseases because it grows above the soil surface (Dinda *et al.*, 2020; Grant, 2022). Furthermore, one of the best agronomic qualities that guarantee yield potential and crop sustainability is garlic varietal compatibility with agro-climatic conditions (Lazo & Tuzon, 2022). Hence, the study was conducted to determine the performance of the Philippines' native garlic varieties in Bacnotan, province of La Union. Specifically, the study aimed to determine the survival rate (%), weight of bulb (g), diameter of bulb (cm), bulb yield (kg) per hectare, bulbil per plant, weight of bulbil (g), bulbil yield (kg) per hectare and identify the virus present in the native garlic varieties.

## Material and methods

*Experimental materials*

The native garlic varieties were obtained from the Department of Agriculture - Bureau of Plant Industry-Central Office (DA-BPI-CO) at 692 San Andres St, Malate, Manila, 1004 Metro Manila, and the Department of Agriculture, Basco, Batanes, Philippines. The native garlic varieties were Ilocos Pink (V1), Romblon (V2), Tan Bolters (V3), Miracle (V4), Ilocos White (V5), Mexican (V6), and Batanes Red (V7). The garlic cloves were separated from each other without removing the outer sheet. Large outer cloves were separated and used as planting materials.

*Experimental location and design*

The experimental area was located at Techno-Demo Farm of Don Mariano Marcos Memorial State University- North La Union Campus (DMMMSU-NLUC), Raois, Bacnotan, La Union, Philippines from October 1, 2019 to March 31, 2020, which has GPS coordinates of 16.72722, 120.35393 at an elevation of about 7 m above sea level (Fig. 1). The experiment was laid out in a 265m² area divided into 3 blocks following the Randomized Complete Block Design (RCBD). Each block was subdivided into 7 equal plots corresponding to the seven garlic varieties with a dimension of 1m x 7m each. Plots were spaced 0.5m apart to ease carrying-out field operations.

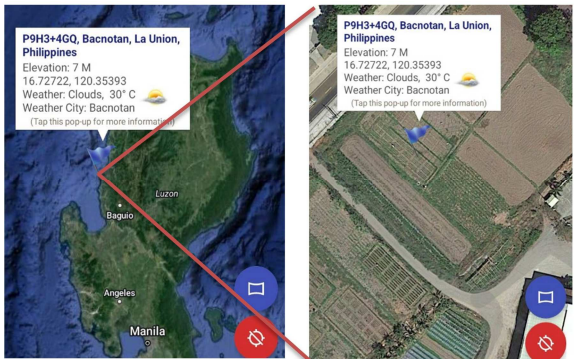


**Fig. 1.** A satellite image showing the experimental area taken from My Elevation application by RDH Software version 1.72.

*Land preparation*

The experimental area was cleared with weeds and foreign materials then was plowed and harrowed thoroughly at a depth of 15cm using a tractor-drawn implement. Plowing and harrowing were done twice in two weeks intervals to granulate the soil and allow the weed seeds to germinate and be controlled easily. Plots were constructed following the dimension of 1m x 7m each elevated up to 10cm. Four furrows were made on each plot spaced at 20cm. Ten-centimeter space was provided on both sides of the plots before furrows.

*Pre-planting treatments and planting*

The garlic cloves of the native garlic varieties were soaked in Benlate fungicide solution and then planted in furrows by dibbling 2/3 of the length of the cloves vertically into the soil spaced at 20cm between hills. Each plot had a total of 136 hills.

*Fertilizer application and mulching*

Carbonized Rice Hull (CRH) and vermicast at 10t/ha rate of application and complete fertilizer (14-14-14) at 60-60-60kg/ha were incorporated into each plot before planting. Urea (46-0-0) at 60-0-0kg/ha was side-dressed during the early bulb formation. A total of 120-60-60kg NPK/ha of inorganic fertilizer was applied. The plots were covered with 2-3cm thick rice straw after planting.

*Weeding and irrigating the plants*

Manual weeding of plots and alleys was done once a week or as needed. Flood irrigation was done at planting followed by once a week thereafter. The plants are irrigated from planting until 2 weeks before harvesting.

*Pesticide application*

Benlate fungicide and Sevin insecticide were applied to plants following the manufacturer's recommendation of application.

*Harvesting and postharvest handling*

Garlic plants were harvested when 75% yellowing of the leaves was observed. The whole plant was manually pulled from the soil. The harvested plants were immediately sun-dried for 4 consecutive days. After drying, bulbs and bulbils were separated manually. Bulbs and bulbils were stored by spreading in a hanging slatted bamboo table under ambient conditions.

*Data gathered*

The following parameters were gathered; (1) survival rate (%), which was taken by counting the number of survived plants per plot at harvesting divided by the total number of cloves planted per plot (136) multiplied by 100; (2) weight of bulb (g), this was taken after the bulbs were sun-dried by weighing 10 randomly selected bulbs per plot using digital weighing scale divided by 10; (3) diameter of bulb (cm), this was taken after the bulbs were sun-dried by measuring 10 randomly selected bulbs per plot using manual vernier caliper divided by 10; (4) bulb yield per hectare, this was taken by extrapolating the yield per plot into yield per hectare (kg) using the formula: Yield inkg per hectare = (Yield per plot (kg) x Area/hectare)/Area per plot; (5) bulbil per plant, this was taken by counting the total bulbil produced per plant of 10 randomly selected plants then divided by 10. Bulbils can be found either inside the garlic neck or in the scape; (6) weight of bulbil, was taken after the bulbils were sun-dried by weighing a single bulbil of 10 randomly selected plants per plot and then dividing by 10 using a digital weighing scale; (7) bulbil yield per hectare, this was taken by extrapolating the yield per plot into yield per hectare (kg) using the formula: Yield inkg per hectare = (Yield per plot (kg) x Area/hectare)/Area per plot and (8) virus present in the bulbil samples, was determined through the assistance of the Molecular Biology Laboratory of Institute of Crop Science of University of the Philippines, Los Baňos, Laguna, Philippines.

*Data analysis*

The data gathered were subjected to Analysis of Variance (ANOVA) in Randomized Complete Block Design (RCBD) with 3 blocks. The significant difference between means was further tested using Tukey's Honest Significant Difference (HSD) Test at 5% and 1% levels of significance. The IRRI-STAR application was used to analyze the data.

**Result and discussion**

*Survival Rate*

The mean survival rate (%) of different native garlic varieties of the Philippines tested in Bacnotan, province of La Union, Philippines is shown in Table 1. $V_1$ - Ilocos Pink gave the highest survival rate with a mean of 93.33% while $V_5$ - Ilocos White gave the lowest with a mean of 55.05%. Highly significant differences were observed between native garlic varieties. Comparison among treatment means showed that $V_1$ - Ilocos Pink gave the highest survival rate of 93.33% but was statistically comparable with $V_6$ – Mexican with a mean of 84.19%. It was followed by $V_4$ – Miracle with a mean of 72.76% and $V_3$ - Tan Bolters with a mean of 64.00%. The lowest survival rate was observed from $V_5$ - Ilocos White with a mean of 55.05% but statistically comparable with $V_2$ – Romblon, $V_3$ - Tan Bolters, $V_4$ – Miracle, and $V_7$ - Batanes Red with means of 56.76%, 64.00%, 72.76% and 55.43%, respectively. The result indicates that V1 - Ilocos Pink and V6 – Mexican grow best in Bacnotan, La Union, Philippines.

**Table 1.** Mean Survival Rate (%) of Different Native Garlic Varieties of the Philippines tested in Bacnotan, province of La Union, Philippines.

| Garlic Varieties | Survival Rate (%) |
|---|---|
| V1- Ilocos Pink | 93.33[a] |
| V2- Romblon | 56.76[c] |
| V3- Tan Bolters | 64.00[bc] |
| V4- Miracle | 72.76[bc] |
| V5- Ilocos White | 55.05[c] |
| V6- Mexican | 84.19[ab] |
| V7- Batanes Red | 55.43[c] |
| F-test | 0.0004 |
| C.V. (%) | 11.92 |

Means with the same letter are not significantly different (Tukey's HSD).

*Bulb Weight (g), Bulb Diameter (cm), and Bulb Yield per Hectare (kg)*

The result revealed significant differences in mean bulb weight (g) and bulb diameter (cm) while highly significant differences were observed in bulb yield per hectare (kg) (Table 2).

Comparison of means revealed that $V_6$ – Mexican produced the heaviest bulb and largest bulb diameter with means of 13.89g and 3.18cm, however, statistically comparable with the other native garlic varieties except $V_7$ - Batanes Red. $V_7$ - Batanes Red produced the lightest bulb and smallest bulb diameter with means of 9.67g and 2.60cm, is statistically comparable with the other native garlic varieties except for $V_6$ – Mexican. As to bulb yield per hectare (kg), V6 – Mexican and V1 - Ilocos Pink comparably produced the highest bulb yield per hectare with means of 2531kg and 2352kg, respectively.

It was followed by V4 – Miracle with a mean of 1924.02kg and V3 - Tan Bolters with a mean of 1561.83kg. V2 – Romblon, V5 - Ilocos White, and V7 - Batanes Red comparably produced the least bulb yield with means of 1267.90kg, 1357.99kg, and 1224.02kg, respectively. The result implies that Mexican and Ilocos Pink are the best among the native varieties tested for bulb production in Bacnotan, La Union, Philippines. The result can also be attributed to the high survival rate of the two varieties during the study.

**Table 2.** Mean bulb weight (g), bulb diameter (cm) and bulb yield per hectare (kg) of the different native garlic varieties of the Philippines tested in Bacnotan, province of La Union, Philippines.

| Garlic Varieties | Bulb Weight (g) | Bulb Diameter (cm) | Bulb Yield per Hectare (kg) |
|---|---|---|---|
| $V_1$ - Ilocos Pink | $11.67^{ab}$ | $2.91^{ab}$ | $2352.84^{a}$ |
| $V_2$ - Romblon | $10.32^{ab}$ | $2.85^{ab}$ | $1267.90^{d}$ |
| $V_3$ - Tan Bolters | $11.22^{ab}$ | $2.94^{ab}$ | $1561.83^{c}$ |
| $V_4$ - Miracle | $12.11^{ab}$ | $2.89^{ab}$ | $1924.02^{b}$ |
| $V_5$ - Ilocos White | $10.56^{ab}$ | $2.82^{ab}$ | $1357.99^{d}$ |
| $V_6$ - Mexican | $13.89^{a}$ | $3.18^{a}$ | $2531.05^{a}$ |
| $V_7$ - Batanes Red | $9.67^{b}$ | $2.60^{b}$ | $1224.02^{d}$ |
| F-test | 0.0331 | 0.0107 | 0.0000 |
| C.V. (%) | 11.51 | 4.78 | 3.74 |

Means with the same letter in a column are not significantly different (Tukey's HSD).

*Bulbil per plant, Weight of Bulbil (g) and Bulbil Yield per Hectare (kg)*

Table 3 presents highly significant differences between the different native garlic varieties in terms of mean bulbil per plant, weight of bulbil (g), and bulbil yield per hectare (kg). A similar trend was observed in the three parameters where V7 - Batanes Red produced the most bulbil per plant, the highest bulbil weight (g), and bulbil yield per hectare (kg) with means of 2.78, 0.89g, and 82.14kg per hectare. It was followed by $V_4$ - Miracle and $V_6$ - Mexican with means of 1.33 and 1.00, 0.66g and 0.55g, and 12.74kg and 10.00kg, respectively. Other native garlic varieties tested did not produce bulbils during the study. The result suggests that Batanes Red, which is a hard-neck garlic variety, is the best among the native garlic varieties tested for bulbil production in Bacnotan, La Union, Philippines. However, soft-neck garlic varieties such as Miracle and Mexican can also produce bulbil in Bacnotan, La Union, Philippines.

**Table 3.** Mean bulbil per plant, weight of bulbil (g), and bulbil yield per hectare (kg) of the different native garlic varieties of the Philippines tested in Bacnotan, province of La Union, Philippines.

| Garlic Varieties | Bulbil Per Plant | Weight of Bulbil (g) | Bulbil Yield per Hectare (kg) |
|---|---|---|---|
| $V_1$ - Ilocos Pink | $0.00^{c}$ | $0.00^{d}$ | $0.00^{c}$ |
| $V_2$ - Romblon | $0.00^{c}$ | $0.00^{d}$ | $0.00^{c}$ |
| $V_3$ - Tan Bolters | $0.00^{c}$ | $0.00^{d}$ | $0.00^{c}$ |
| $V_4$ - Miracle | $1.33^{b}$ | $0.66^{b}$ | $12.74^{b}$ |
| $V_5$ - Ilocos White | $0.00^{c}$ | $0.00^{d}$ | $0.00^{c}$ |
| $V_6$ - Mexican | $1.00^{b}$ | $0.55^{c}$ | $10.00^{b}$ |
| $V_7$ - Batanes Red | $2.78^{a}$ | $0.89^{a}$ | $82.14^{a}$ |
| F-test | 0.0000 | 0.0000 | 0.0000 |
| C.V. (%) | 16.88 | 3.56 | 9.00 |

Means with the same letter in a column are not significantly different (Tukey's HSD).

*Viral Diseases Screening in the Garlic Bulbils*

Garlic bulbils were collected from the experimental area at Bacnotan, La Union, and different growing areas in the province of La Union for virus indexing. The samples were sent to the Molecular Biology Laboratory of the Institute of Crop Science of the University of the Philippines, Los Baños, Laguna, Philippines. Results showed that garlic bulbils from the municipalities of Caba, Aringay, and Bacnotan tested positive for allexivirus and OYDV (Table 4).

The presence of these viruses in the bulbils may be attributed to the planting materials infected with the virus as the bulbils are genetically identical to the parent. Garlic is propagated vegetatively, therefore it is susceptible to the accumulation of a range of viruses including members of the genera Potyvirus, Carlavirus, and Allexivirus (Bereda *et al.*, 2017). The allexivirus-associated diseases are usually mild and, in many cases, symptomless (Zavriev, 2008). Garlic plants infected with OYDV exhibit yellow mosaic symptoms on the leaves (Araújo *et al.*, 2018).

**Table 4.** Result of garlic bulbils virus indexing.

| Location | Variety | Allexivirus | OYDV |
|---|---|---|---|
| San Simon, Aringay, La Union | Batanes Red | + | + |
| San Juan, Aringay, La Union | Batanes Red | + | + |
| Caba, La Union | Batanes Red | + | + |
| Bacnotan, La Union | Batanes Red | + | + |

Legend: + = positive with the specific virus disease

*Agro-meteorological Data*

The average monthly minimum and maximum temperature (°C), relative humidity (%), and rainfall (mm) were recorded during the study (Fig. 2). The temperature during the study ranges from 20.89°C to 31.23°C. The highest minimum and maximum temperatures were recorded in October at 23.9°C and 31.23°C, while the lowest minimum and maximum temperatures were recorded in February and November at 20.89°C and 30.03°C, respectively.

The relative humidity during the study ranges from 83.61% to 85.65%. The highest relative humidity was recorded in November and December with a similar average of 85.65% while the lowest was recorded in February at 83.61%. As to the rainfall reading, the highest rainfall was recorded in November with 208 mm, followed by October with 15.20mm and December with 3.80mm. There was no rainfall in January and February. The total rainfall accumulated was 227mm. The agro-meteorological data were collected from DMMMSU-PAGASA Agro-met Station at Don Mariano Marcos Memorial State University-North La Union Campus (DMMMSU-NLUC), Sapilang, Bacnotan, La Union, Philippines.

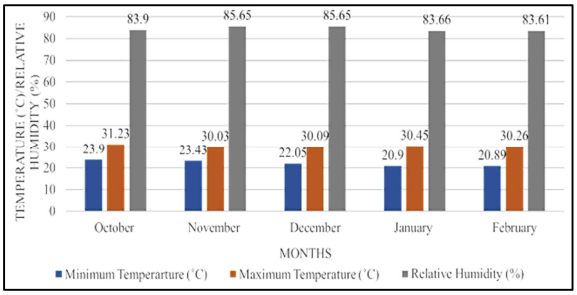


**Fig. 2.** Agro-meteorological data (temperature and relative humidity) during the conduct of the study.

## Conclusion

Based on the result of the study, it is concluded that, among the Philippine native garlic varieties tested, Mexican and Ilocos Pink can significantly produce higher survival rates (%) and bulb yield per hectare (kg) while the Batanes Red can produce higher bulbil yield in Bacnotan, La Union, Philippines. It was also noted that soft-neck garlic varieties such as Miracle and Mexican can also produce bulbil. There were two virus diseases detected from the bulbil samples of the Batanes Red variety, namely; allexivirus and onion yellow dwarf virus (OYDV).

## Recommendation(S)

Based on the result of the study, Mexican and Ilocos Pink varieties are recommended for bulb production while the Batanes Red variety is recommended for bulbil production by farmers in Bacnotan, La Union, Philippines. However, studies to improve the survival rate and minimize disease infection should be conducted to improve the quality and quantity of bulb and bulbil production of the native garlic varieties in Bacnotan, La Union, Philippines.

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**APPENDIX A. Table A1.** Mean survival rate (%) of different native garlic varieties tested in Bacnotan, La Union, Philippines.

| Entry | Block | | | Total | Mean |
|---|---|---|---|---|---|
| | I | II | III | | |
| $V_1$ - Ilocos Pink | 85.14 | 100.00 | 94.86 | 280.00 | 93.33 |
| $V_2$ - Romblon | 61.71 | 56.00 | 52.57 | 170.29 | 56.76 |
| $V_3$ - Tan Bolters | 67.43 | 61.71 | 62.86 | 192.00 | 64.00 |
| $V_4$ - Miracle | 78.86 | 86.86 | 52.57 | 218.29 | 72.76 |
| $V_5$ - Ilocos White | 52.00 | 57.71 | 55.43 | 165.14 | 55.05 |
| $V_6$ - Mexican | 77.14 | 98.86 | 76.57 | 252.57 | 84.19 |
| $V_7$ - Batanes Red | 54.29 | 58.29 | 53.71 | 166.29 | 55.43 |
| Block Total | 476.57 | 519.42 | 448.57 | | |
| Grand Total | | | | 1444.57 | |
| Grand Mean | | | | | 481.52 |

**Table A2.** Mean weight of bulb per plant (g) of different native garlic varieties tested in Bacnotan, La Union, Philippines.

| Entry | Block | | | Total | Mean |
|---|---|---|---|---|---|
| | I | II | III | | |
| $V_1$ - Ilocos Pink | 14.67 | 9.67 | 10.67 | 35.01 | 11.67 |
| $V_2$ - Romblon | 12.00 | 8.67 | 10.30 | 30.97 | 10.32 |
| $V_3$ - Tan Bolters | 15.00 | 10.33 | 8.33 | 33.66 | 11.22 |
| $V_4$ - Miracle | 14.67 | 12.00 | 9.67 | 36.34 | 12.11 |
| $V_5$ - Ilocos White | 13.67 | 9.33 | 8.67 | 31.67 | 10.56 |
| $V_6$ - Mexican | 14.67 | 15.00 | 12.00 | 41.67 | 13.89 |
| $V_7$ - Batanes Red | 11.00 | 8.67 | 9.33 | 29.00 | 9.67 |
| Block Total | 95.68 | 73.67 | 68.97 | | |
| Grand Total | | | | 238.32 | |
| Grand Mean | | | | | 79.44 |

**Table A3.** Mean bulb diameter (cm) of different native garlic varieties tested in bacnotan, La Union, Philippines.

| Entry | Block | | | Total | Mean |
|---|---|---|---|---|---|
| | I | II | III | | |
| $V_1$ - Ilocos Pink | 3.15 | 2.76 | 2.81 | 8.72 | 2.91 |
| $V_2$ - Romblon | 3.05 | 2.71 | 2.80 | 8.56 | 2.85 |
| $V_3$ - Tan Bolters | 3.25 | 2.83 | 2.75 | 8.83 | 2.94 |
| $V_4$ - Miracle | 3.10 | 2.90 | 2.67 | 8.67 | 2.89 |
| $V_5$ - Ilocos White | 3.18 | 2.57 | 2.70 | 8.45 | 2.82 |
| $V_6$ - Mexican | 3.15 | 3.31 | 3.08 | 9.54 | 3.18 |
| $V_7$ - Batanes Red | 2.75 | 2.43 | 2.61 | 7.79 | 2.60 |
| Block Total | 21.63 | 19.51 | 19.42 | | |
| Grand Total | | | | 60.56 | |
| Grand Mean | | | | | 20.19 |

**Table A4.** Mean bulb yield per hectare (kg) of different native garlic varieties tested in Bacnotan, La Union, Philippines.

| Entry | Block | | | Total | Mean |
|---|---|---|---|---|---|
| | I | II | III | | |
| $V_1$ - Ilocos Pink | 2116.08 | 2419.51 | 2522.94 | 7058.54 | 2352.848 |
| $V_2$ - Romblon | 1138.05 | 1301.23 | 1364.41 | 3803.69 | 1267.898 |
| $V_3$ - Tan Bolters | 1395.13 | 1595.16 | 1695.20 | 4685.49 | 1561.830 |
| $V_4$ - Miracle | 1711.90 | 1957.35 | 2102.81 | 5772.06 | 1924.020 |
| $V_5$ - Ilocos White | 1129.44 | 1291.32 | 1653.21 | 4073.97 | 1357.989 |
| $V_6$ - Mexican | 2271.98 | 2597.71 | 2723.45 | 7593.14 | 2531.045 |
| $V_7$ - Batanes Red | 1041.39 | 1190.69 | 1439.99 | 3672.06 | 1224.020 |
| Block Total | 10803.96 | 12352.98 | 13502.00 | | |
| Grand Total | | | | 36658.95 | |
| Grand Mean | | | | | 1745.664 |

**Table A5.** Mean number of bulbil per plant of different native garlic varieties tested in Bacnotan, La Union, Philippines.

| Entry | Block | | | Total | Mean |
|---|---|---|---|---|---|
| | I | II | III | | |
| $V_1$ - Ilocos Pink | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| $V_2$ - Romblon | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| $V_3$ - Tan Bolters | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| $V_4$ - Miracle | 1.11 | 1.33 | 1.55 | 3.99 | 1.33 |
| $V_5$ - Ilocos White | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| $V_6$ - Mexican | 1.00 | 1.00 | 1.00 | 3.00 | 1.00 |
| $V_7$ - Batanes Red | 2.50 | 2.78 | 3.06 | 8.34 | 2.78 |
| Block Total | 4.61 | 5.11 | 5.61 | | |
| Grand Total | | | | 15.33 | |
| Grand Mean | | | | | 0.73 |

**Table A6.** Mean weight of bulbil (g) of different native garlic varieties tested in Bacnotan, La Union, Philippines.

| Entry | Block | | | Total | Mean |
|---|---|---|---|---|---|
| | I | II | III | | |
| $V_1$ - Ilocos Pink | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| $V_2$ - Romblon | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| $V_3$ - Tan Bolters | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| $V_4$ - Miracle | 0.64 | 0.66 | 0.68 | 1.98 | 0.66 |
| $V_5$ - Ilocos White | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| $V_6$ - Mexican | 0.53 | 0.55 | 0.57 | 1.65 | 0.55 |
| $V_7$ - Batanes Red | 0.87 | 0.89 | 0.91 | 2.67 | 0.89 |
| Block Total | 2.04 | 2.10 | 2.16 | | |
| Grand Total | | | | 6.30 | |
| Grand Mean | | | | | 0.30 |

**Table A7.** Mean bulbil yield per hectare (kg) of different native garlic varieties tested in Bacnotan, La Union, Philippines.

| Entry | Block | | | Total | Mean |
|---|---|---|---|---|---|
| | I | II | III | | |
| $V_1$ - Ilocos Pink | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| $V_2$ - Romblon | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| $V_3$ - Tan Bolters | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| $V_4$ - Miracle | 12.41 | 15.41 | 10.41 | 38.23 | 12.742 |
| $V_5$ - Ilocos White | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| $V_6$ - Mexican | 9.00 | 11.00 | 10.00 | 29.99 | 9.996 |
| $V_7$ - Batanes Red | 79.94 | 81.94 | 84.54 | 246.41 | 82.136 |
| Block Total | 101.34 | 108.34 | 104.94 | | |
| Grand Total | | | | 314.62 | |
| Grand Mean | | | | | 14.982 |

**APPENDIX B-** Results of Statistical Analysis from IRRI-STAR v 2.0.1

**Table B1.** Analysis of variance on survival rate (%) of different native garlic varieties tested in Bacnotan, La Union, Philippines.

| Source of Variation | df | Sum of Square | Mean Square | F Value | Pr(> F) |
|---|---|---|---|---|---|
| Block | 2 | 363.9104 | 181.9552 | 2.71 | 0.1071ns |
| Variety | 6 | 4171.0692 | 695.1782 | 10.34 | 0.0004** |
| Error | 12 | 806.5322 | 67.2110 | | |
| Total | 20 | 5341.5118 | | | |

ns not significant **highly significant c.v (%)=11.92

**Table B2.** Analysis of variance on weight of bulb (g) per plant of different native garlic varieties tested in Bacnotan, La Union, Philippines.

| Source of Variation | df | Sum of Square | Mean Square | F Value | Pr(> F) |
|---|---|---|---|---|---|
| Block | 2 | 58.0931 | 29.0465 | 17.04 | 0.0003** |
| Variety | 6 | 35.0118 | 5.8353 | 3.42 | 0.0331* |
| Error | 12 | 20.4582 | 1.7049 | | |
| Total | 20 | 113.5631 | | | |

*significant **highly significant c.v (%)=11.51

**Table B3.** Analysis of variance on bulb diameter (cm) of different native garlic varieties tested in Bacnotan, La Union, Philippines.

| Source of Variation | df | Sum of Square | Mean Square | F Value | Pr(> F) |
|---|---|---|---|---|---|
| Block | 2 | 0.4470 | 0.2235 | 11.78 | 0.0015** |
| Variety | 6 | 0.5392 | 0.0899 | 4.73 | 0.0107** |
| Error | 12 | 0.2278 | 0.0190 | | |
| Total | 20 | 1.2139 | | | |

**highly significant c.v (%)= 4.78

**Table B4.** Analysis of Variance on the Bulb Yield per Hectare (kg) of Different Native Garlic Varieties tested in Bacnotan, La Union, Philippines.

| Source of Variation | Df | Sum of Square | Mean Square | F Value | Pr(> F) |
|---|---|---|---|---|---|
| Block | 2 | 523767.3221 | 261883.6610 | 61.34 | 0.0000** |
| Variety | 6 | 5105280.6552 | 850880.1092 | 199.30 | 0.0000** |
| Error | 12 | 51233.0160 | 4269.4180 | | |
| Total | 20 | 5680280.9933 | | | |

**highly significant c.v. (%)= 3.74

**Table B5.** Analysis of variance on the number of bulbil per plant of different native garlic varieties tested in Bacnotan, La Union, Philippines.

| Source of Variation | Df | Sum of Square | Mean Square | F Value | Pr(> F) |
|---|---|---|---|---|---|
| Block | 2 | 0.0714 | 0.0357 | 2.35 | 0.1374ns |
| Variety | 6 | 20.3010 | 3.3835 | 222.88 | 0.0000** |
| Error | 12 | 0.1822 | 0.0152 | | |
| Total | 20 | 20.5546 | | | |

**highly significant c.v. (%)= 16.88

**Table B6.** Analysis of variance on weight of bulbil (g) of different native garlic varieties tested in Bacnotan, La Union, Philippines.

| Source of Variation | df | Sum of Square | Mean Square | F Value | Pr(> F) |
|---|---|---|---|---|---|
| Block | 2 | 0.0010 | 0.0005 | 4.50 | 0.0348* |
| Variety | 6 | 2.7006 | 0.4501 | 3938.38 | 0.0000** |
| Error | 12 | 0.0014 | 0.0001 | | |
| Total | 20 | 2.7030 | | | |

*significant **highly significant c.v. (%)= 3.56

**Table B6.** Analysis of variance on bulbil yield per hectare (kg) of different native garlic varieties tested in Bacnotan, La Union, Philippines.

| Source of Variation | df | Sum of Square | Mean Square | F Value | Pr(> F) |
|---|---|---|---|---|---|
| Block | 2 | 3.5010 | 1.7505 | 0.96 | 0.4093ns |
| Variety | 6 | 16313.6106 | 2718.9351 | 1496.27 | 0.0000** |
| Error | 12 | 21.8057 | 1.8171 | | |
| Total | 20 | 16338.9173 | | | |

ns not significant **highly significant c.v. (%)= 9.00

**APPENDIX C-** Local Agro-meteorological Data during the study

**Table C1.** Monthly temperature range (˚c), average relative humidity (%) and rainfall (mm) from October 2019 to March 2020.

| Month & Year | Temperature Range (˚C) | Relative Humidity (%) | Rainfall (mm) |
|---|---|---|---|
| October 2019 | 23.90-31.23 | 83.90 | 15.80 |
| November 2019 | 23.43-30.03 | 85.65 | 208.60 |
| December 2019 | 22.05-30.09 | 85.65 | 3.80 |
| January 2020 | 20.90-30.45 | 83.66 | 0.00 |
| February 2020 | 20.89-30.26 | 83.61 | 0.00 |
| March 2020 | 23.21-32.31 | 74.29 | 0.00 |

Source: DMMMSU-PAGASA Agromet Station, Bacnotan, La Union