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Field Assessment of Fertilization, Nursery, and Crop Management Practices among Tomato (*Solanum lycopersicum* L.) Growers in the Ilocos Provinces, Philippines

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Growth and yield of many economically important vegetables like tomatoes are heavily influenced by crop management practices, particularly fertilizer application, irrigation scheme, and pest management. To attain maximum tomato yields and increase farmers' profits, these crop production components must be optimized in local farm levels. Before optimization measures can be conducted, baseline information on prevailing practices needs to be evaluated. To assess the nutrient management and other crop production practices of tomato farmers in the Ilocos provinces, Philippines, on-farm surveys were conducted in 16 and 18 barangays planting fresh-type and processing-type tomatoes, respectively. The study involved a total of 88 tomato farmers who underwent key informant interviews regarding their seed and crop establishment practices, nutrient management, pest occurrence, and their perceived yield losses due to pests. Nitrogen and phosphorus application rates by farmers in Ilocos Sur are generally higher by 19% while potassium application rate is higher by 33% compared to those in Ilocos Norte. Farmers of both fresh-type and processing-type tomatoes apply mostly nitrogen and potassium fertilizers and limiting phosphate-containing fertilizers. Ammonium sulfate, muriate of potash, and foliar fertilizer are among the common fertilizer choices for farmers in both provinces and tomato types. Ilocos Sur farmers practice higher seeding rates (400 – 600 g ha^{-1}) while Ilocos Norte farmers mostly use 250 g ha^{-1} seeds. Farmers also consider diseases to be the most yield-reducing biotic stress, while weeds are perceived to cause only minimal yield losses.

Keywords: crop management, fertilizer practices, fresh-type tomato, Philippines, processing-type tomato

INTRODUCTION

Originating from the Andean region and domesticated in Mexico, the cultivated tomato (*Solanum lycopersicum*) dispersed across the world continents during the colonial periods (OECD 2017; Saavedra et al. 2017; Ouattara and Konate 2024). It has since become a worldwide vegetable crop of major economic importance, with uses ranging from fresh culinary applications to the global processed food industry, and now emerging uses in the nutraceutical and medical industries (Sattar et al. 2024; Collins et al. 2022). Combined world production in 2022 was recorded at 186.11 MMT with China, India, and Turkey as the top three tomato-producing countries (FAO 2023 - with major processing by Our World in Data). By type, production in 2021 for fresh consumption exceeded 150 MMT against 40 MMT for processing-type tomato (Branthôme 2023). In the Philippines, tomato is one of the top cultivated vegetable crops, with its volume of production in 2023 estimated at 219.31 kMT (PSA 2024a). The major tomato-producing regions in 2019 were Ilocos Region (73.32 kMT), Northern Mindanao (48.53 kMT), Central Luzon (31.45 kMT), CALABARZON (16.02 kMT), and Western Visayas (11.48 kMT) (DA 2024). Recently, Ilocos Region and Central Luzon have consistently been the top producers of tomato in the country (PSA 2024b). The average per hectare yield in 2015 was 13.29 MT ha^{-1} (PSA 2016); however, local high yield level is below the world average of 36.6 MT ha^{-1} and far from high-yielding countries producing 60 – 450 MT ha^{-1} (Branthôme 2023).

Growth and yield of many vegetable crops are heavily influenced by crop management protocols such as fertilization. The Solanaceae—to which tomato belongs—are touted as heavy feeders taking up large amount of nutrients from the soil (Ortas 2013). A yield of 1 t of fresh fruit requires 2.5 – 3.0 kg N, 0.2 – 0.3 kg P, and 3.0 – 3.5 kg K (Hegde 1997). Hence, it is common to use high amounts of inorganic fertilizers that are applied as basal fertilizers and/or as side-dress. In the Ilocos Region, conventional tomato growers apply an average of 205 kg N, 191 kg P_2O_5, and 59 kg K_2O ha^{-1} in tomato (Lutap and Atis 2013). These rates are relatively higher than the existing recommended rates by the Department of Science and Technology-Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD 2015) and Northern Foods Corporation (NFC) which are 165-95-215 and 116-40-120 kg ha^{-1} NPK, respectively (N.D. Mendoza, personal communication, January 2018). Additionally, planting distance, seedling age, and pest management influence the yield potential of tomato crops. Amare and Gebremedhin (2020) concluded that various row spacings result in varying yield levels and fruit quality. Moreover, 3 – 4 wk or 20 – 28 d was found to be the optimum transplanting age for tomato seedlings (Leskovar et al. 1991; Shopova and Cholakov 2014; Jaiswal et al. 2017). Similarly, biotic stresses significantly influence growth, yield, and fruit quality of tomatoes wherever they are grown. Tomato production in the Philippines is also affected by a number of insect pests (Navasero and Navasero 2015) and diseases (Dolores et al. 2015). Competition with various weed species (Fabro and Barcial 2015) may also cause severe yield losses if left unmanaged.

Production protocols that seek to optimize tomato production yields through effective and efficient nutrient and crop management practices can further enhance the return on investment (ROI) of local tomato growers—technologies such as site-specific nutrient management (SSNM) can increase fertilizer use efficiency and may reduce soil fertility degradation through balanced application of mineral nutrients such as N, P, and K (Khurana et al. 2008). However, the development of such intervention packages is based on localized baseline information. Following the rapid rural appraisal approach, this study was therefore conducted to establish baseline information on the common practices of managing fertilization, seedlings and nurseries, and biotic stresses among the fresh- and processing-type tomato growers in the Ilocos provinces.

MATERIALS AND METHODS

Study location. The study was conducted in the northwest region of the Philippines (Region I), particularly in the provinces of Ilocos Sur and Ilocos Norte. In Ilocos Norte, respondents came from 17 barangays (smallest administrative geographic unit) of six municipalities, while respondents in Ilocos Sur came from 17 barangays of seven municipalities. The municipalities, barangays, and the number of respondents for the fresh and processing tomato types for each province are summarized in Table 1.

Table 1. Municipalities and barangays in Ilocos Norte and Ilocos Sur, Philippines where the survey was conducted and the number of respondents (in parenthesis) per municipality.

Fresh-type tomato	Processing-type tomato
Ilocos Norte	Ilocos Norte
Municipality of Vintar (7)	Municipality of Paoay (5)
· Barangay Balbolala	· Barangay Cabagoan
· Barangay Namuroc	· Barangay Dolores
· Barangay Ester	
Municipality of Piddig (9)	Municipality of Piddig (5)
· Barangay Ab-abut	· Barangay Sucsuquen
· Barangay Sucsuquen	· Barangay Tonoton
· Barangay Tangaon	
· Barangay Tagipuro	
· Barangay Pugao	
Municipality of Dingras (7)	Municipality of Dingras (10)
· Barangay Capasan	· Barangay Suyo
· Barangay Suyo	· Barangay Capasan
· Barangay Palyas	
Ilocos Sur	Ilocos Sur
Municipality of San Juan (6)	Municipality of Sinait (10)
· Barangay Baliw	· Barangay Purag
	· Barangay Duyayat
	· Barangay Namnaman
	· Barangay Recudo
Municipality of Magsingal (1)	Municipality of Magsingal (2)
· Barangay Panay Norte	· Barangay Panay Norte
Municipality of Narvacan (8)	Municipality of Narvacan (10)
· Barangay Rivadavia	· Barangay Quinarayan
· Barangay Orence	· Barangay Orense
· Barangay Sta. Lucia	· Barangay Sta Lucia
	· Barangay Bantay-agut
	· Barangay Marga-ay
	Municipality of Sto. Domingo (8)
	· Barangay Parada
	· Barangay Paras

Field survey and documentation, respondent sampling, and survey schedule. Documentation of the cultivation practices of Ilocos tomato growers was conducted following a face-to-face interview using a questionnaire. The locations selected were the major tomato production areas in the region for processing-type tomatoes identified by Northern Foods Corporation (NFC), a government-owned and controlled corporation (GOCC). Until its abolition in 2021, NFC was the only facility in the Philippines that processed tomatoes into paste using its flagship variety, "Ilocos Red".

Respondents were not randomly selected as the list was provided by NFC, consisting of tomato farmers who had a contract growing agreement with the corporation. Growers who were available and were willing to participate in the survey were selected as respondents. The survey interview was conducted from 2018 to 2019. A total of 15 fresh-type and 30 processing-type tomato growers from Ilocos Sur and 23 fresh-type and 20 processing-type tomato growers from Ilocos Norte were interviewed. The questionnaire focused on the practices of tomato growers relating to fertilizer management and application rates, seeding rates and nursery management, planting distance, perceived losses due to biotic stresses, and estimated yields.

Data processing, analysis and presentation. Responses relating to the data variables such as type of commercial fertilizer materials used, application rates for NPK, seeding rate, planting distances, seedling age, perceived losses due to insect pests, perceived losses due to diseases, and perceived losses due to weeds were summarized and expressed as percentages and/or averages by province and by cultivar type. The frequency of each class in the range of responses for a given variable was calculated by simple percentage derivation. Where unit of measure is necessary, summary values and/or averages were expressed either in kg ha^{-1}, g ha^{-1} or t ha^{-1}. Data processing, generation of summary statistics, and data visualization by graph were all done in Microsoft Excel.

RESULTS

Commonly Used Fertilizers and Corresponding Application Rates

The proportion of respondents to the type of commercial fertilizer used is shown in Fig. 1. In both provinces, respondents identified five commonly available commercial fertilizers in granular form: complete, ammonium phosphate (AP), urea, ammonium sulfate (AS), and muriate of potash (MOP). Except for fresh-type growers in Ilocos Sur, AP, AS, and MOP are the most preferred fertilizer materials in both provinces, with about 53% – 87% of the respondents listing all three materials. The almost equal number of respondents for fresh-type growers in Ilocos Sur using AP and complete fertilizers implies that growers are divided between using these two fertilizer materials. Interestingly, tomato growers of both variety types, especially those from Ilocos Sur, more commonly use commercial foliar fertilizers (57% – 83%), more so than urea, complete, and AP fertilizers. For fresh-type growers in Ilocos Sur, a maximum of 33% use urea fertilizers and a maximum of 43% use complete fertilizers. Most respondents source the major nutritional elements (NPK) from AP and MOP fertilizers. The source of N can be chosen between AP fertilizers, which provide both nitrogen and phosphorus, and AS fertilizers, which supply nitrogen along with sulfur. In both provinces and for both variety types, complete and urea fertilizers are not as popular among respondents. Slightly more fresh-type growers in Ilocos Norte use AP, AS, and MOP fertilizers than processing-type growers. Similarly, more fresh-type growers in Ilocos Sur use AS and MOP fertilizers, but they have a lower preference for AP fertilizers compared to processing-type growers.

Fig. 2 shows the average amounts of NPK fertilizers applied and the corresponding average yields. Generally, Ilocos Sur growers use higher application rates ranging from 36 kg ha^{-1} of P to 147 kg ha^{-1} of N. In contrast, Ilocos Norte rates range from 34 kg ha^{-1} P to 99 kg ha^{-1} N. Data shows that Ilocos Sur growers apply 26, 9, and 42 kg more N, P, and K fertilizers, respectively. In both provinces, P is the least supplied for both fresh- and processing-types with the highest application rate at 57 kg ha^{-1} by processing-type growers in Ilocos Sur, while N is the most supplied element with application rates of 106 – 140 kg ha^{-1} by processing-type growers in Ilocos Norte. The estimated average yields conform with the fertilization rates—Ilocos Sur has a higher average yield for both variety types compared to Ilocos Norte. Average yields in Ilocos Sur are higher by 27.2 t for the processing-type and by 7.18 t per ha for the fresh-type.

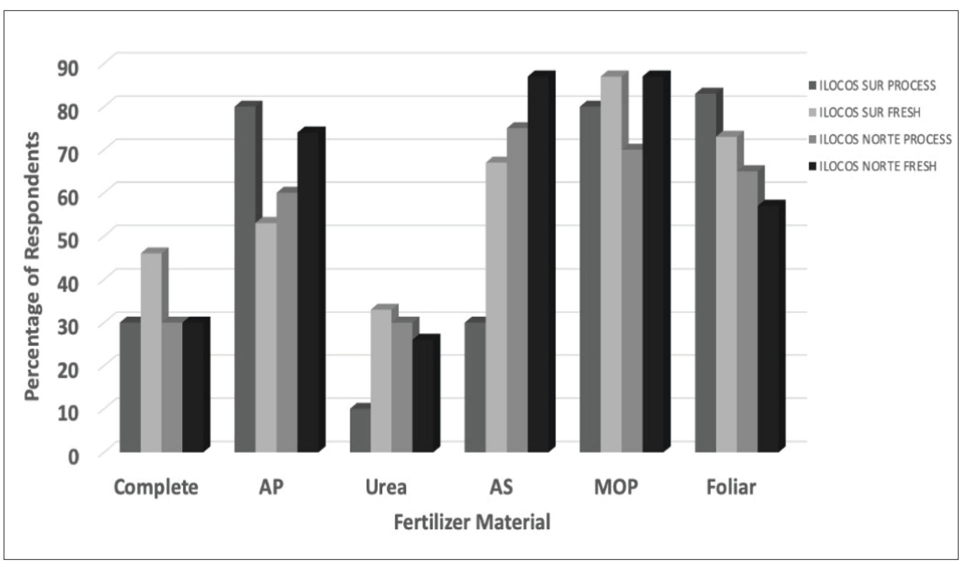

Fig. 1. Proportion of respondents to the specific fertilizer commonly used by tomato type in the Ilocos provinces, Philippines. AP: ammonium phosphate, AS: ammonium sulfate, MOP: muriate of potash.

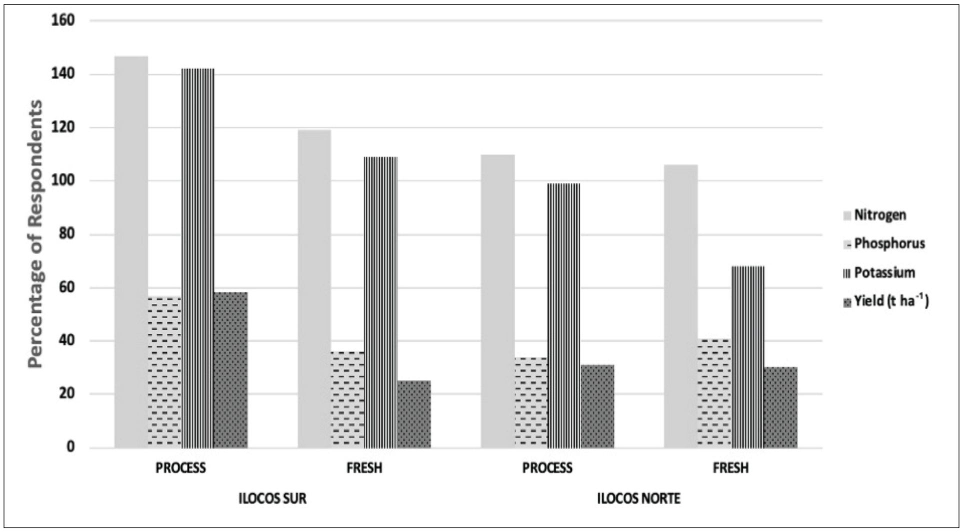

Fig. 2. Average amounts of NPK fertilizers applied and corresponding yield by tomato type in the Ilocos provinces, Philippines.

Commonly Practiced Seeding Rates and Transplanting Ages

Figs. 3A and 3B show the proportion of respondents practicing the different seeding rates for processing-type and fresh-type tomatoes, respectively. For the processing-type, responses can be categorized into four amounts of seed used per ha with modal seeding rates of 250 and 400 g (Fig. 3A). Generally, most respondents in Ilocos Sur practice seeding rates of 400–>600g. In contrast, the majority (55%) of Ilocos Norte respondents practice a lower seeding rate at 250 g per ha. Moreover, 20% of Ilocos Norte tomato growers practice a seeding rate of 200 g compared to only 7% of Ilocos Sur tomato growers. On the other hand, seeding rates for the fresh-type are interestingly variable, with Ilocos Norte having seven seeding rates from 100 to 400g per ha and Ilocos Sur having 6 seeding rates (Fig. 3B). The modal value, however, was 350 g for both provinces. The seeding rate of Ilocos Norte fresh-type growers is 100 g higher than that of the processing-type growers. A sizable proportion of fresh-type growers also practice seeding rates of 200 g or less compared to processing-type growers. For both provinces, the modal seeding rates for fresh-type were 100, 150, and 350 g seeds per ha. Seedling age, on the other hand, can be grouped into ranges (Fig. 4). It was observed that in both provinces, most respondents transplant 21–25-d-old seedlings for both variety types, although there are slightly more (48%) fresh-type growers in Ilocos Norte who transplant 10–20-d-old seedlings than those who transplant 21–25-d-old seedlings (39%).

Commonly Practiced Planting Distances

The proportion of respondents practicing the different planting distances for the processing-type variety is shown in Fig. 5A. Ilocos Sur growers practice as many as seven distances and Ilocos Norte growers practice five distances. Three modal distances were identified for Ilocos Sur growers: 30 x 30, 30 x 75, and 20 x 100 cm. Ilocos Norte growers, on the other hand, practice slightly wider planting distances with modal distances of 35 x 50, 30 x 75, 20 x 100, and 50 x 100 cm. For the fresh-type variety, planting distances are even more variable (Fig. 5B). Ilocos Norte growers listed 13 distances from 30 x 30 cm to 90 x 150 cm, while Ilocos Sur growers mentioned five planting distances. For both provinces, however, the modal value was 30 x 100 cm. Ilocos Norte growers listed the three widest planting distances, namely 60 x 60, 75 x 90, and 90 x 150 cm, while Ilocos Sur growers listed the narrowest distance at 30 x 30 cm. A large majority of the Ilocos Sur growers (60%), however, practice a planting distance of 30 x 100 cm, similar to Ilocos Norte growers (32%).

Perceived Yield Losses Due to Biotic Stresses

Respondents were asked to estimate the extent of damage caused by different pest types on the yield of their tomato crops under their current growing practices. Their responses showed different perspectives—most of the Ilocos Sur respondents growing the processing-type perceive yield loss due to insect pests to be only about 20% or less, but those growing the fresh-type perceive yield loss due to insect pests to be around 40%, 60%, or 80% (Fig. 6A). Ilocos Norte growers also had varying responses, but most values were below the above-mentioned estimates for both variety types. Fifty-two percent (52%) of fresh-type growers and 25% of processing-type growers estimate yield loss to be at ~60%, while 20% of processing-type growers estimate yield loss to exceed 80%.

Estimates of yield loss due to diseases as perceived by tomato farmers varied from less than 10% to as much as over 80% (Fig. 6B). Of the Ilocos Sur respondents, about 40% of processing-type growers estimate yield loss to be 21% – 40%, while 33% of fresh-type growers estimate yield loss in the same range, and another 33% estimated a loss of 41% – 60%. In contrast, 60% of processing-type growers in Ilocos Norte estimate yield loss to be over 80%, while 43% of fresh-type growers estimate yield loss at 41% – 60%, and another 22% estimate a loss of 21% – 40%.

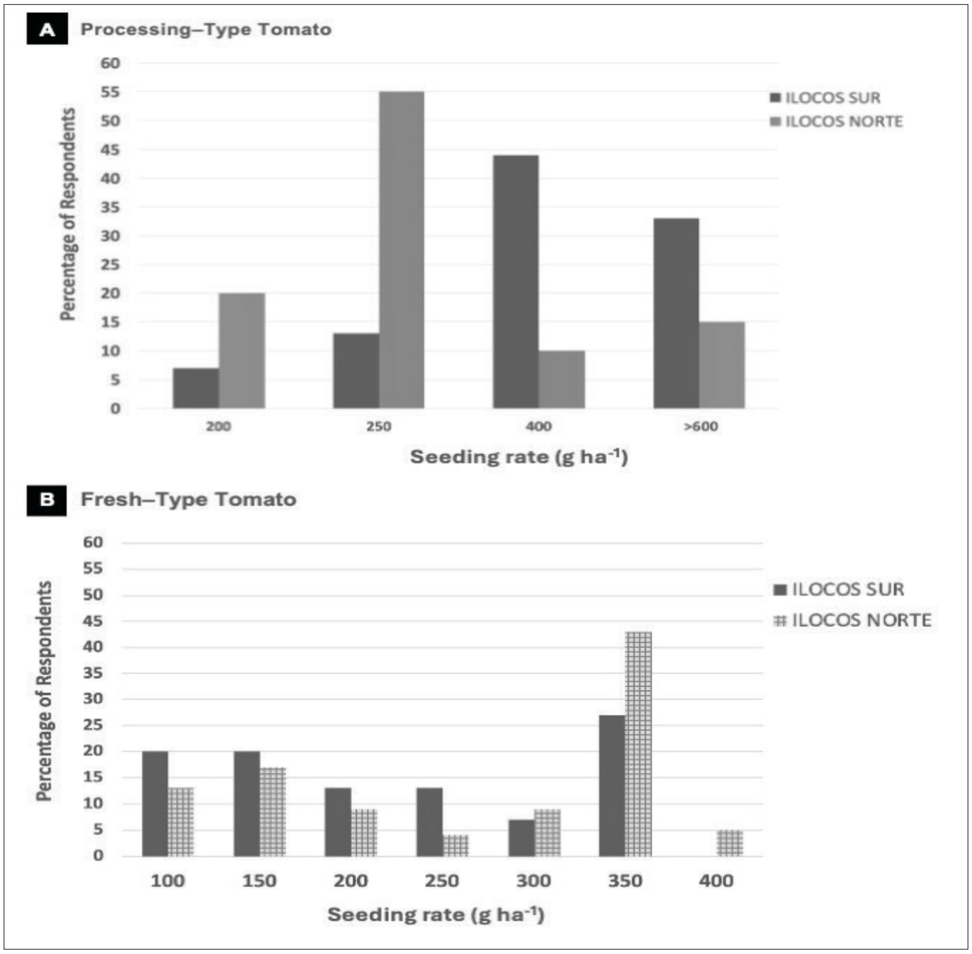

Fig. 3. Proportion of respondents practicing different seeding rates for processing-type (A) and fresh-type (B) tomatoes in the Ilocos provinces, Philippines.

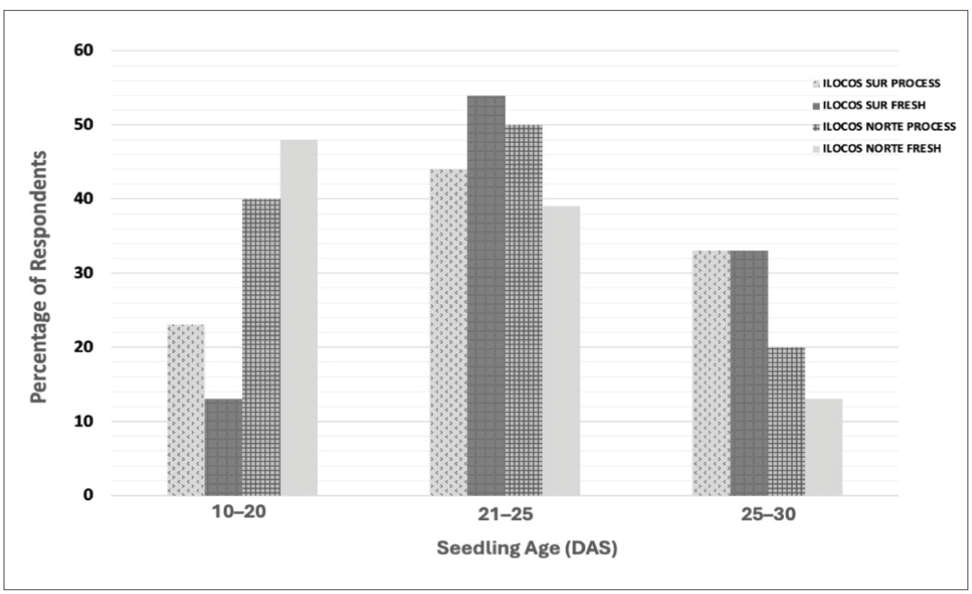

Fig. 4. Proportion of respondents practicing different transplanting ages by tomato type in the Ilocos provinces, Philippines. Days After Sowing (DAS).

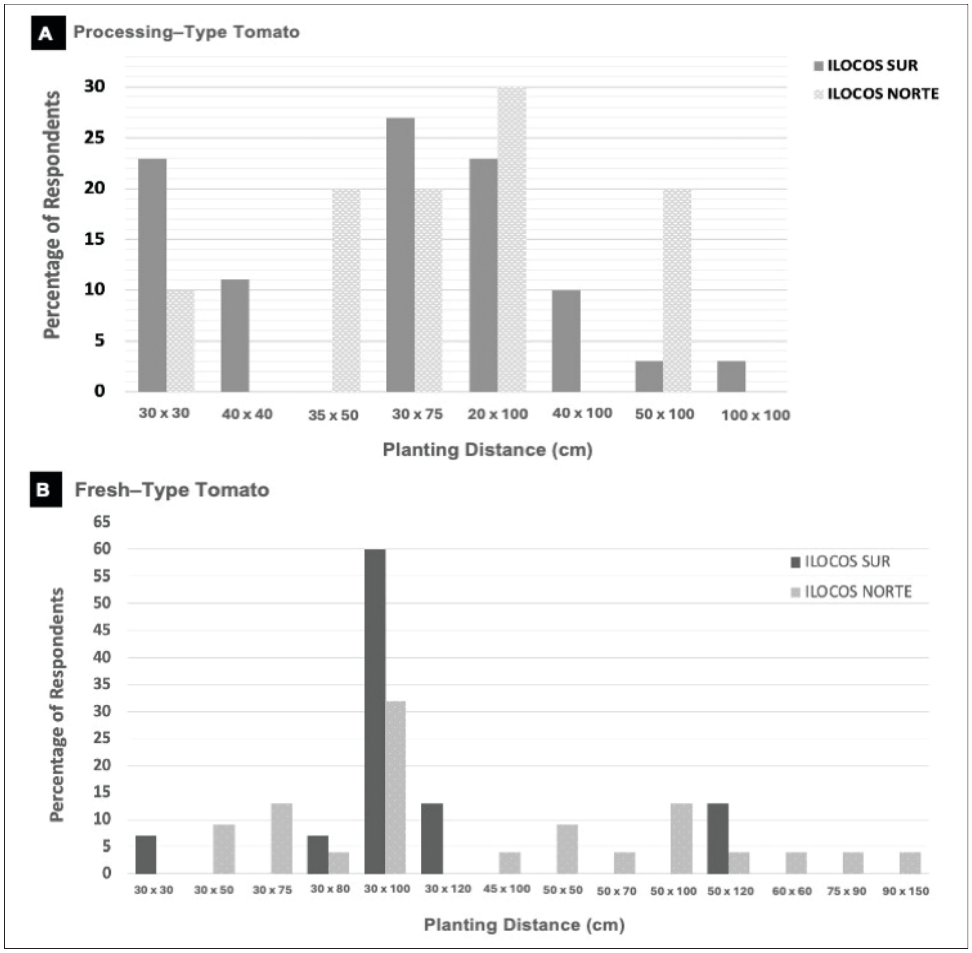

Fig. 5. Proportion of respondents practicing different planting distances for processing-type (A) and fresh-type (B) tomatoes in the Ilocos provinces, Philippines.

Perceived yield losses due to weeds are presented in Fig. 6C. Estimates varied from less than 10% to over 80%. The majority (37%) of processing-type growers in Ilocos Sur perceive yield loss to be either around 21% – 40% or less than 10%. Estimates varied widely for the fresh-type growers, although 40% of them perceive yield loss to be 41% – 60%. Ilocos Norte growers, on the other hand, estimate yield loss to be less than 10% for most processing-type growers and 41% – 60% and 21% – 40% for fresh-type growers.

To summarize, diseases are perceived to cause the most damage at 20% – 40% losses for Ilocos Sur growers (Fig. 7A) to as much as 80% for most Ilocos Norte growers (Fig. 7B). Most respondents estimate yield losses due to insect pests and weeds to be only 20% or even less than 10%. Weeds are considered to have the least impact on yield, with the majority of respondents (33% in Ilocos Sur and 55% in Ilocos Norte) estimating yield losses to be only about 10% for both provinces. Yield losses due to insect pests are perceived variably in Ilocos Norte, with modal estimates ranging from 21% to 80%, while the majority of Ilocos Sur growers estimate a yield loss of 20% or less.

DISCUSSION

The fertilizer management practices of Ilocos tomato growers allow them to produce feasible yields as affirmed by the respondents and their common practices. The N rates noted in this survey are similar to those reported in previous studies. Etissa et al. (2013) found that 105 kg of N could produce 56 t ha^{-1} of fruit yield while Sigaye et al. (2022) reported that 138 kg ha^{-1} of N could produce 73 t ha^{-1} of fruit yield. Beyene and Amare (2019) also concluded that 150 kg ha^{-1} of N produced the maximum yield, while 100 kg ha^{-1} was the optimum rate. A considerable number of farmer respondents confirmed that they use foliar fertilizer as an added nutrient, which is almost the same number of farmer respondents using granular-type fertilizers. This addition of foliar fertilizer may have contributed to obtaining a feasible yield level. Moreover, the role of N in crop growth is well-established. It is a primary component of cell constituents such as enzymes, chlorophyll, and vitamins, among others (Role of nitrogen in tomato production n.d.). Nishat et al. (2021) also found that N significantly increases the growth and yield of tomatoes. In particular, it helps improve fruit size, quality, taste, color, and storage quality.

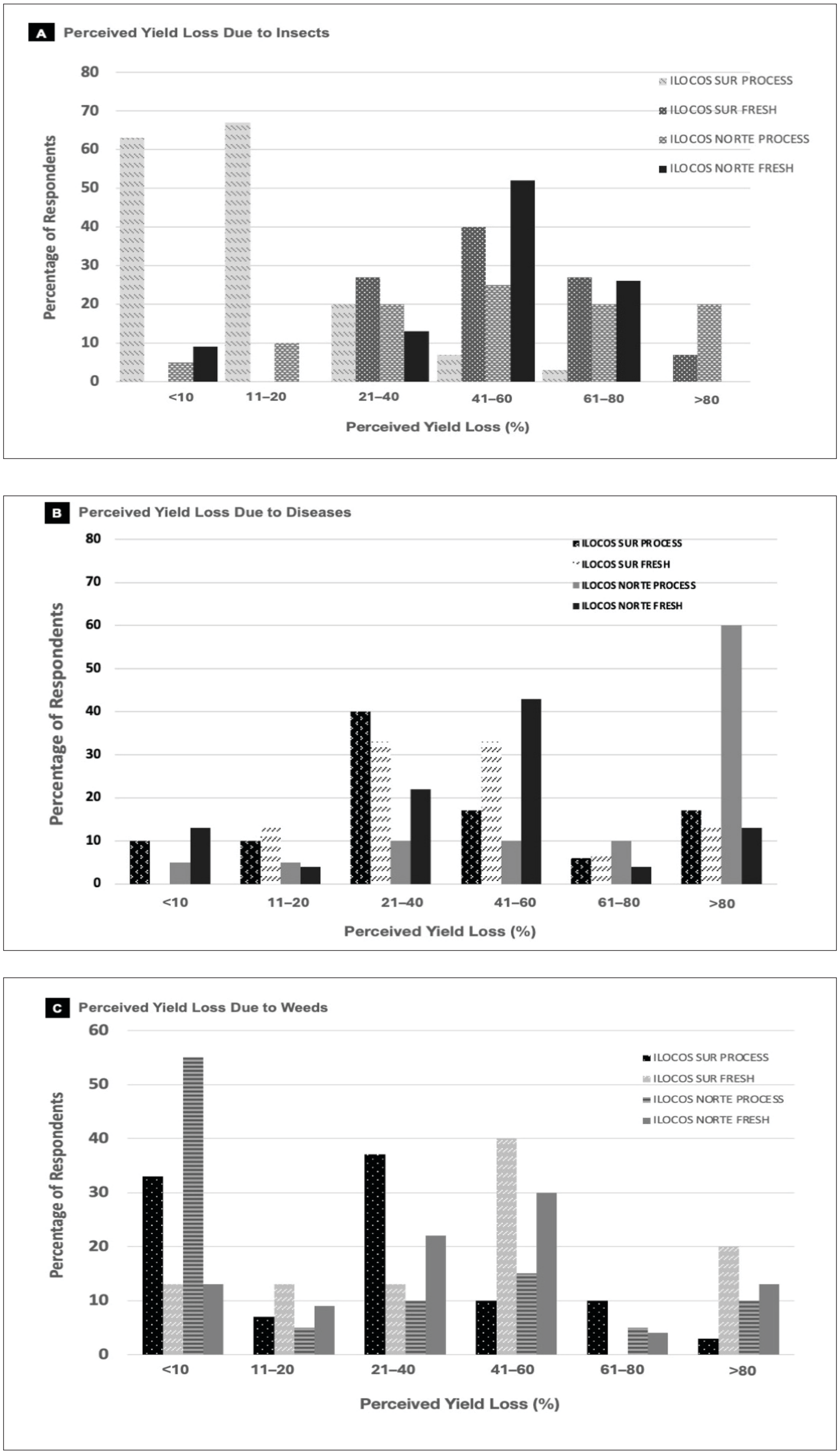

Fig. 6. Proportion of respondents and their perceived yield losses due to insect pests (A), diseases (B), and weeds (C) in the Ilocos provinces, Philippines.

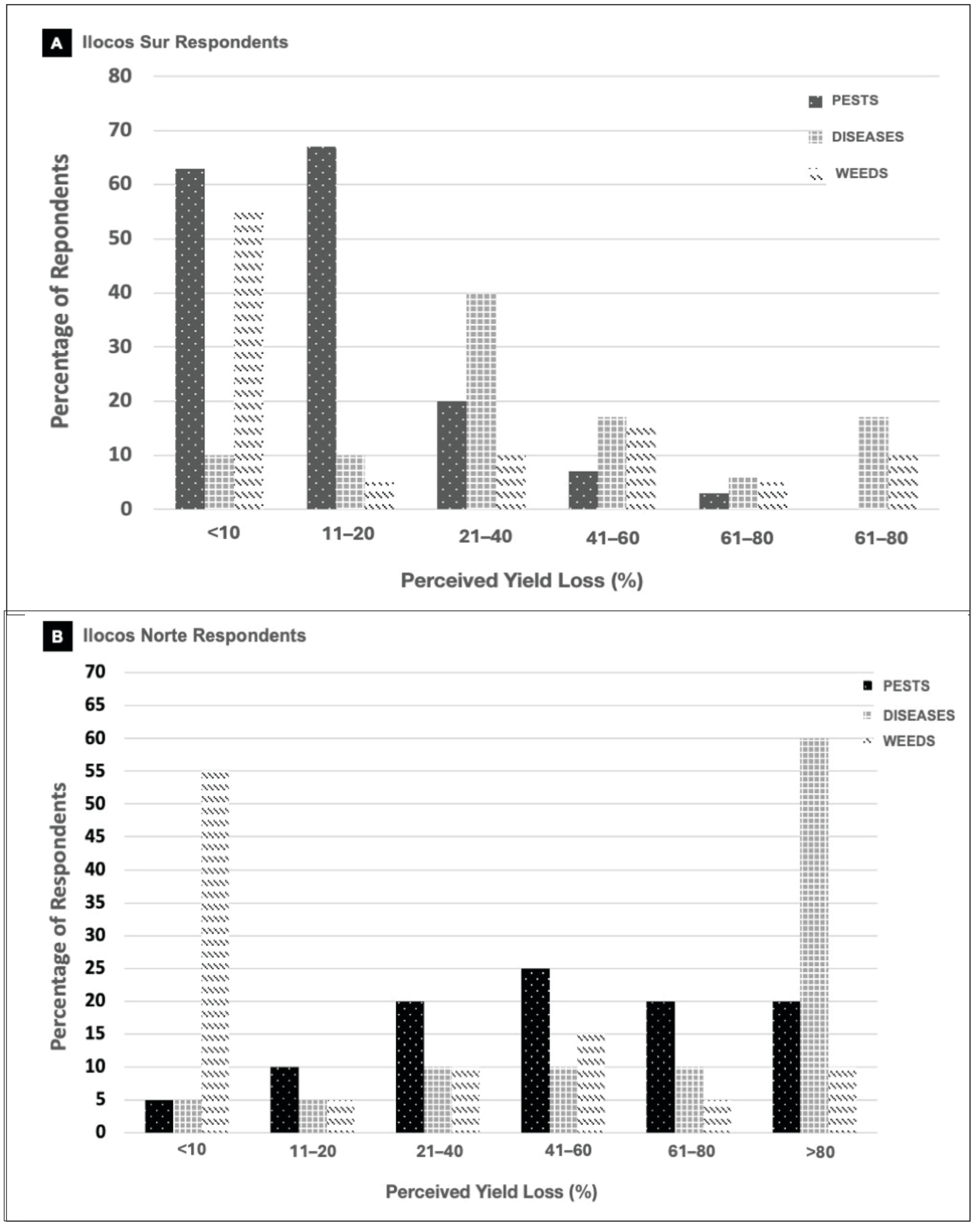

Fig. 7. Proportion of respondents in Ilocos Sur (A) and Ilocos Norte (B) and their perceived yield losses due to biotic stresses.

Similarly, Ilocos tomato growers apply high amounts of K, with application rates ranging from 80 to 137 kg ha^{-1}. Application rates for K were observed to be the second highest after N, while P has the lowest application rate, ranging only from 22 to 50 kg ha^{-1}. Some tomato growers recommend similar rates of high N and K and low P (Juan Magsasaka 2021). These rates are also mentioned in the Department of Agriculture (DA)-Regional Field Office 2 Tomato Production Guide (DA 2017). Etissa et al. (2013) concluded that 40 kg ha^{-1} of P produced the maximum yield, while Zhu et al. (2017) recommended slightly higher rates at 66 – 87 kg ha^{-1} to achieve desirable growth parameters. Naz et al. (2019) recommended an even higher P rate at 130 kg ha^{-1} as appropriate for farming conditions in Peshawar, Pakistan. Similarly, Iqbal et al. (2011) recommended the same rate to achieve high tomato yields. However, Ahmad et al. (2015) reported that yield, firmness, and fruit weight, among others, significantly increased at 60 kg ha^{-1} of K. While P and K application rate recommendations may vary widely, practices by Ilocos tomato growers fall within these ranges. The estimated average yields were also found to correspond to the amounts of fertilizer applied. Ilocos Norte growers reported lower yields for both variety types compared to Ilocos Sur growers, which may be due to the lower amounts of NPK applied.

Seeding rates and nursery management practices vary widely among growers by province and by variety type. A large number of respondents tend to practice higher seeding rates starting at 250 g ha^{-1} up to over 400 g ha^{-1} seeds, which are higher than the commonly recommended rates for tomato.

The DA Regional Field Office 2 recommends a seeding rate of 100 – 200g ha^{-1} for the Cagayan Valley region (DA 2017). Commercial seed producers also recommend a seeding rate of 200 g ha^{-1} (Tomato seed rate n.d.; Tomato production guide 2024), while the Agritech Portal of Tamil Nadu Agricultural University (2023) recommends a slightly lower rate of 150 g ha^{-1} for hybrid varieties. While some Ilocos tomato growers adhere to these recommended seeding rates, others continue to use higher rates, resulting in higher seed costs. The respondents reported several reasons including experience with low seed viability, provision for seedling mortality during the nursery stage, and provision for early replanting of dead transplants. In rice cultivation, high seeding rates are often associated with low seed quality, compensation for seed losses due to damages from birds, rats, and snails, and reducing wide open spaces that may be taken over by weeds (IRRI 2024).

The modal planting distances observed in this study differed between the fresh-type and the processing-type growers but were generally consistent for both provinces. The most common planting distance for fresh-type tomatoes corresponds to approximately 30 000 plants ha^{-1}, while for processing-type tomatoes, the modal values correspond to about 40 000 and 50 000 plants ha^{-1}. This suggests that respondents maintain a higher planting density for the processing-type compared to the fresh-type. Interestingly, however, some processing-type growers in Ilocos Sur also practice planting densities below the typical 40 000 plants ha^{-1}, while some Ilocos Norte growers use even lower planting densities at around 20 000 plants ha^{-1}.

Transplanting age also varies among Ilocos tomato growers, with some transplanting as early as about 20 d after sowing (DAS) to as late as 30 DAS. This aligns with several reports indicating that the majority follow the commonly recommended transplanting age of around 3 – 4 wk after sowing (Agble 1995; DA 2017; Jaiswal et al. 2017; Swett 2017; Modupeola et al. 2019). These observations suggest potential avenues for technical interventions in tomato-growing practices aimed at improving and standardizing seeding rates, seedling nursery management, and early transplanting care.

Results also showed that yield losses due to biotic stresses affecting tomato cultivation are a concern among Ilocos growers at varying levels. Diseases are perceived to cause the greatest yield loss while weeds are perceived to cause the least. Regarding yield loss due to insect pests, tomato growers in Ilocos Norte perceive greater losses than those in Ilocos Sur.

Of these biotic stresses, diseases are more difficult to manage and monitor, thus causing more damage. Ma et al. (2023) stated that diseases from soil-borne pathogens such as Fusarium oxysporum are regarded as major threats to tomato cultivation worldwide, causing yield losses of 10% – 80%. The Department of Agriculture (DA) (2017) listed Fusarium wilt and bacterial wilt as among the most prevalent and destructive diseases of tomato in the Cagayan Valley region. Soil-borne pathogens are difficult to control due to their persistence in the soil (Ma et al. 2023). Moreover, host resistance, which is the primary approach to disease management in tomato, is generally limited among the current commercial tomato varieties available in Ilocos.

On the other hand, insect pests and weeds are easier to detect and monitor; hence, control measures can be immediately applied. The majority (67%) of respondents identified whiteflies, fruitworms/borers, and leaf miners as the most common insect pests causing crop damage. The Department of Agriculture-Agricultural Training Institute (DA-ATI) (2008) reported thrips, fruitworms, and whiteflies as the most common pests of tomato in the Philippines. Similarly, Balabag et al. (2019) listed whiteflies and fruitworms as the prevalent insect pests of tomato in Lanao del Sur. Navasero and Navasero (2015) identified a number of insect pests of tomato in the Philippines but also listed fruitworms as the most significant since they cause direct damage to the fruit. However, fruitworms can be effectively managed through the use of many registered insecticides.

Yield losses due to weeds are generally perceived to be low, although respondents presented a wide range of estimates from less than 10% to over 80%. Labonite et al. (2015) stated that yield loss estimates due to weeds may be 40% – 60% while Mohamed and Abdalla (2023) cited a wider range of 32% – 96%. The general perception of low yield loss due to weeds may be associated with the relatively easier management of weeds compared to insects and diseases. These management practices include good land preparation, manual or mechanical follow-on weeding, chemical control (Lanini et al. 2011), and use of mulch (CTA 2004; Labonite et al. 2015). Herbicide application, manual weeding, mechanical weeding, or using hand tools are among the common weed management practices of Ilocos tomato growers, both for processing-type and fresh-type tomatoes.

CONCLUSION AND RECOMMENDATIONS

Fertilizer choices and management, seeding and seedling establishment, and the perceived effects of biotic stresses of tomato growers in the Ilocos provinces, Philippines were assessed in this study. Results showed that the fertilizer rates adopted by farmers do not align with the recommended guidelines for tomato cultivation. Farmers typically apply higher amounts of nitrogen and potassium, often using ammonium sulfate or ammonium phosphate as their primary nitrogen sources. Potassium is primarily supplied through muriate of potash, while phosphorus is derived from the application of complete fertilizers and ammonium phosphate. Nutrient application rates, particularly for nitrogen and potassium, show a gradient from low to high, perhaps due largely to the financial capacity of individual farmers to purchase fertilizers. Alongside granular fertilizers, foliar fertilizers are also extensively used, holding the same level of importance among Ilocos tomato growers. Seeding rates vary among farmers, reflecting differences in seed quality, nursery skills, and practices. This variability may also indicate a cautious approach, ensuring sufficient seedlings are available for later replanting. Likewise, transplanting distances employed by farmers exhibit significant variability. Perceived yield losses due to biotic stresses range widely, from as little as 10% to over 80%, with the latter implying near-total crop failure. These findings highlight the influence of management practices on the success of crop production and underscores the value of gathering baseline information that can be used as a basis to refine crop production components that are key in realizing optimum yield. Among the commercial tomato cultivation practices that need to be refined are the use of optimum fertilization rates, improvement in seeding and seedling nursery practices by improved seed quality and variety, and improvement in after transplanting crop management practices to minimize yield reduction effects of biotic stresses. It is also recommended to examine the costs and benefits of the popularity of foliar fertilization practices among Ilocos tomato growers.

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REFERENCES CITED

AGBLE F. 1995. The effect of transplanting age and seasons on tomato production. Ghana J Agric Sci. 24–27:7–10. https://www.ajol.info/index.php/gjs/article/view/117472/107039.

AHMAD N, SARFRAZ M, FAROOQ U, ARFAN-UL-HAQ M, MUSHTAQ MZ, ALI MA. 2015. Effect of potassium and its time of application on yield and quality of tomato. Int J Sci Res Pub. 5(9):1–4. https://www.ijsrp.org/research-paper-0915/ijsrp-p45120.pdf.

AMARE G, GEBREMEDHIN H. 2020. Effect of plant spacing on yield and yield components of tomato (*Solanum lycopersicum* L.) in Shewarobit, Central Ethiopia. Scientifica. 2020: 8357237. doi:10.1155/2020/8357237.

BALABAG NM, ANUB RR, SABADO EM. 2019. Survey of insects and other arthropods in tomato (*Lycopersicon esculentum* Mill.) in Lanao del Sur province, ARMM, Philippines. Int J Sci Manage Stud. 2(3):45–53. https://www.ijsmsjournal.org/2019/volume-2%20issue-3/ijsms-v2i3p104.pdf.

BEYENE N, AMARE T. 2019. Effect of different level of nitrogen fertilizer on growth, yield and yield component of tomato (*Lycopersicon esculentum* Mill.) at West Showa Zone, Oromia, Ethiopia. World J Agric Sci. 15(4):249–253. doi:10.5829/idosi.wjas.2019.249.253.

BRANTHÔME FX. 2023. Worldwide (total fresh) tomato production in 2021. https://www.tomatonews.com/en/worldwide-total-fresh-tomato-production-in-2021_2_1911.html.

COLLINS EJ, BOWYER C, TSOUZA A, CHOPRA M. 2022. Tomatoes: an extensive review of the associated health impacts of tomatoes and factors that can affect their cultivation. Biology. 11(2):239. doi:10.3390/biology11020239.

[CTA] Technical Centre for Agricultural and Rural Cooperation (ACP-EU). 2004. Rural radio resource pack no. 04/1: weed control. Suffolk (United Kingdom): WRENmedia.

[DA] Department of Agriculture. 2017. Tomato production guide. Cagayan (Philippines): High Value Crops Development Program, Department of Agriculture - Regional Field Office No. 02. https://cagayanvalley.da.gov.ph/wp-content/uploads/2018/02/Tomato.pdf.

[DA] Department of Agriculture. 2024. Investment guide for tomato. Philippines: Agribusiness and Marketing Assistance Service, Agribusiness Promotion Division, Department of Agriculture. https://www.da.gov.ph/wp-content/uploads/2021/04/Investment-Guide-for-Tomato.pdf.

[DA-ATI] Department of Agriculture - Agricultural Training Institute. 2008. Tomato production guide. Information, education and communication materials series no. 7-10. Philippines: Department of Agriculture - Agricultural Training Institute and Department of Agriculture - Regional Field Office No. 02. https://ati2.da.gov.ph/e-extension/content/sites/default/files/2023-03/Tomato.pdf.

DOLORES M, DALISAY TU, OCAMPO CR, DELA CUEVA FM. 2015. Chapter 9: diseases of tomato. In: Dela Cueva FM, Pascual CB, Bajet CM, Dalisay TU, editors. Pests and diseases of economically important crops in the

Philippines. Laguna (Philippines): Pest Management Council of the Philippines, Inc. - University of the Philippines Los Baños.

ETISSA E, DECHASSA N, ALAMIREW T, ALEMAYEHU T, DESALEGN L. 2013. Growth and yield components of tomato as influenced by nitrogen and phosphorus fertilizer applications in different growing seasons. Ethiop J Agric Sci. 23:57–77. https://www.ajol.info/index.php/ejas/article/view/142855.

FABRO LE, BARCIAL PM. 2015. Chapter 23: weeds of vegetables. In: Dela Cueva FM, Pascual CB, Bajet CM, Dalisay TU, editors. Pests and diseases of economically important crops in the Philippines. Laguna (Philippines): Pest Management Council of the Philippines, Inc. - University of the Philippines Los Baños.

[FAO] Food and Agriculture Organization of the United Nations. 2023. – with major processing by Our World in Data. Tomato production – FAO [dataset]. Food and Agriculture Organization of the United Nations, “Production: Crops and livestock products” [original data]. https://ourworldindata.org/grapher/tomato-production.

HEGDE DM. 1997. Nutrient requirements of solanaceous vegetable crops. Proceedings of the International Conference on Managing Soil Fertility for Intensive Vegetable Production Systems in Asia; 1996 Nov 4–10; Tainan, Taiwan. Tainan (Taiwan): Asian Vegetable Research and Development Center.

IQBAL M, NIAMATULLAH M, YOUSAF I, MUNIR M, KHAN MZ. 2011. Effect of nitrogen and potassium on growth, economical yield and yield components of tomato. Sarhad J Agric. 27(4):545–548.

[IRRI] International Rice Research Institute. 2024. Seed rate (high). IRRI Rice Knowledge Bank. http://www.knowledgebank.irri.org/decision-tools/rice-doctor/rice-doctor-fact-sheets/item/seed-high-rate.

JAISWAL AK, SINGH JP, TOMAR S, ABHISHEK, THAKUR N. 2017. Effect of seedlings age on growth, yield attributes and yield of tomato (*Lycopersicon esculentum* Mill.). Int J Curr Microbiol App Sci. 6(9):1521–1524. doi:10.20546/ijcmas.2017.609.185.

KHURANA HS, PHILLIPS SB, BIJAY-SINGH, ALLEY MM, DOBERMANN A, SIDHU AS, YADVINDER-SINGH, PENG S. 2008. Agronomic and economic evaluation of site-specific nutrient management for irrigated wheat in northwest India. Nutr Cycl Agroecosys. 82:15–31. doi:10.1007/s10705-008-9166-2.

LABONITE MA, MCDOUGALL S, ROGERS G, LABONITE JG, JOMOC DB, OTARA MC. 2015. Utilization of coconut fronds for weed and insect pest management in tomato production. Int J Environ Rural Dev. 6(2):23–28. https://iserd.net/ijerd62/IJERD%206-2-05.pdf.

LANINI WT, HEMBREE KJ, MIYAO G, STODDARD CS. 2011. Agriculture: tomato pest management guidelines: integrated weed management. https://ipm.ucanr.edu/agriculture/tomato/integrated-weed-management/#gsc.tab=0.

LESKOVAR DI, CANTLIFFE DJ, STOFFELLA PJ. 1991. Growth and yield of tomato plants in response to age of transplants. J Amer Soc Hort Sci. 116(3):416–420. https://journals.ashs.org/downloadpdf/journals/jashs/116/3/article-p416.pdf.

LUTAP LA, ATIS MI. 2013. Pest management in vegetable production: the case of the rainfed lowlands in Ilocos Norte. MMSU Sci Technol J. 3(1):87–107. https://research.mmsu.edu.ph/stjournal/vol3_pest_management_vegetable.pdf.

MA M, TAYLOR PWJ, CHEN D, VAGHEFI N, HE JZ. 2023. Major soilborne pathogens of field processing tomatoes and management strategies. Microorganisms. 11(2):263. doi:10.3390/microorganisms11020263.

JUAN MAGSASAKA. 2021. Tomato (*kamatis*) cultivation guide: all you need to know in planting, growing and harvesting tomato. https://www.juanmagsasaka.com/2020/12/tomato-kamatis-cultivation-guide-all.html.

MODUPEOLA TO, TAKIM FO, AKINTOYE HA, OLAOYE GO. 2019. Effects of transplanting age on growth and yield of tomato varieties commonly grown in south-western Nigeria. Niger J Hort Sci. 24(3):13–25. https://hortson.org.ng/images/Journals/2019volume/Modupeola_et_al_2019.pdf.

MOHAMED IA, ABDALLA RM. 2023. Weed control, growth, and yield of tomato after application of metribuzin and different pendimethalin products in Upper Egypt. J Soil Sci Plant Nut. 23:924–937. doi:10.1007/s42729-022-01093-3.

NAVASERO MC, NAVASERO MV. 2015. Chapter 21: insect pests of tomato. In: Dela Cueva FM, Pascual CB, Bajet CM, Dalisay TU, editors. Pests and diseases of economically important crops in the Philippines. Laguna (Philippines): Pest Management Council of the Philippines, Inc. University of the Philippines Los Baños.

NAZ N, KHAN I, GUL B, AYUB G, JAN F, JANG N, SHUAIB M. 2019. Response of tomato (*Lycopersicon esculentum* Mill.) growth to different phosphorous levels and sowing dates. Acta Ecol Sin. 39(1):30–35. doi:10.1016/j.chnaes.2018.06.004.

NISHAT NJ, BISWAS S, MEHEDI MNH, RAKIB A, AKTER T. 2021. Effect of nitrogen and phosphorus on growth, yield and quality of tomato. Int J Multidiscip Perspect. 2(1):33–40. doi:10.18801/ijmp.020121.06.

[OECD] Organization of Economic Cooperation and Development. 2017. Tomato (*Solanum lycopersicum*). In: Safety assessment of transgenic organisms in the environment, volume 7: OECD Consensus Documents. Paris (France): OECD Publishing. doi:10.1787/23114622.

ORTAS I. 2013. Influences of nitrogen and potassium fertilizer rates on pepper and tomato yield and nutrient uptake under field conditions. Sci Res Essays. 8(23):1048–1055. doi:10.5897/SRE11. 579.

OUATTARA SSS, KONATE M. 2024. The tomato: a nutritious and profitable vegetable to promote in Burkina Faso. Alex Sci Exch J. 45(1):11–20. doi:10.21608/asejaiqjsae.2024.332758.

[PCAARRD] Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development. 2015. Tomato production guide. PCAARRD Information Bulletin No. 55/2015.

[PSA] Philippine Statistics Authority. 2016. Updated costs of production of selected agricultural commodities 2013-2015. Quezon City (Philippines): Philippine Statistics Authority. https://psa.gov.ph/system/files/main-publication/2013-2015%2520CRS%2520of%2520Selected%2520Commodities.pdf.

[PSA] Philippine Statistics Authority. 2024a. Selected statistics on agriculture and fisheries: 2019-2023. Quezon City (Philippines): Philippine Statistics Authority. https://psa.gov.ph/publication/selected-statistics-on-agriculture-and-fisheries.

[PSA] Philippine Statistics Authority. 2024b. Technical notes on Q1 2024. Major vegetables and root crops quarterly bulletin. https://psa.gov.ph/vegetable-root-crops/tomato.

ROLE OF NITROGEN IN TOMATO PRODUCTION. n.d. Yara. https://www.yara.us/crop-nutrition/tomato/role-of-nitrogen/.

SAAVEDRA TM, FIGUEROA GA, CAUIH JGD. 2017. Origin and evolution of tomato production *Lycopersicon esculentum* in México. Cienc Rural. 47(3) e20160526. doi:10.1590/0103-8478cr20160526.

SATTAR S, IQBAL A, PARVEEN A, FATIMA E, SAMDANI A, FATIMA H, IQBAL MS, WAJID M. 2024. Tomatoes unveiled: a comprehensive exploration from cultivation to culinary and nutritional significance [preprint]. Qeios. doi:10.32388/CP4Z4W.2.

SHOPOVA N, CHOLAKOV D. 2014. Effect of the age and planting area of tomato (*Solanum licopersicum* L.) seedlings for late field production on the physiological behavior of plants. Bulg J Agric Sci. 20(1):173–177. https://www.agrojournal.org/20/01-28.pdf.

SIGAYE MH, LULIE B, MEKURIA R, KEBEDE K. 2022. Effects of nitrogen and phosphorus fertilization rates on tomato yield and partial factor productivity under irrigation condition in Southern, Ethiopia. Int J Res Stud Agric Sci. 8(4):1–7. doi:10.20431/2454-6224.0804001.

SWETT R. 2017. Tomato transplanting tips. https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=23543.

TAMIL NADU AGRICULTURAL UNIVERSITY. 2023. Tomato (*Solanum lycopersicum*). Solanaceae. https://agritech.tnau.ac.in/horticulture/horti_vegetables_tomato_seed.html.

TOMATO PRODUCTION GUIDE. 2024. Ramgo Seeds. https://ramgoseeds.com/vegetable/tomato/.

TOMATO SEED RATE. n.d. Tomatocultivation.com. https://tomatocultivation.com/Tomato-Seed-Rate.html.

ZHU Q, OZORES-HAMPTON M, LI Y, MORGAN K, LIU G, MYLAVARAPU RS. 2017. Effect of phosphorus rates on growth, yield, and postharvest quality of tomato in a calcareous soil. HortScience. 52(10):1406–1412. doi:10.21273/HORTSCI12192-17.