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Assessment of Mechanization Level of Onion Production in Nueva Ecija

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Abstract

The study was conducted to assess the level of mechanization of different field operations of onion production in Nueva Ecija, Philippines. Specifically, it aimed to determine the current situation of onion production in five (5) major onion-producing municipalities; assess the level of human-powered, draft-powered, and mechanically powered mechanization technology used; analyze the mechanization index and land productivity to determine the possible hindrances of mechanization; and provide recommendations relative to the mechanization of onion production in the province. The five (5) study sites are major onion-producing municipalities in Nueva Ecija, namely: Laur, Gabaldon, Bongabon, Rizal, and Talavera, with production areas of 411.9 ha, 1,587 ha, 2,695.5 ha, 1,107 ha, and 520 ha, respectively, with a total of 6,321.4 ha. An average of 3.25 hp per ha is available for onion production.

The mechanization technology at 0.79kW/ha of human power, 0.10 kW/ha of animal power, and 1.90 kW/ha mechanical power are utilized in field operations with a total of 2.79 kW/ha per field operation. A total of 55.11 kW/ha is utilized for onion production with 23.51 kW/ha coming from mechanical power which is applied during land preparation. Moreover, the mechanization index of the onion production in Nueva Ecija was computed at 0.715 or 71.5%, labor productivity at 1.375 kW/ha, and land productivity at 9.06 MT/ha. Meanwhile, a major hindrance on mechanization of onion production in Nueva Ecija is the high cost of machines available in the market which is not affordable to farmers who have small farm sizes. Thus, they prefer to borrow or rent machines to perform their farm operations. Land preparation, spraying, and irrigation are among the field operations that utilizes mechanical power; whereas, transplanting, crop establishment, and harvesting are done manually. This situation requires the farmers to hire laborers when needed.

Key Words: labor productivity, land productivity, mechanization index, mechanization level, onion production

Introduction

Other than rice, the province of Nueva Ecija in Central Luzon is the top producer of onion in the Philippines. According to the Philippine Statistics Authority in 2017, Nueva Ecija accounted for 62.65% or 115,474.37 metric tons (MT) of onion harvested. A common and important condiment in food preparation,

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the onion is one of the main sources of income of farmers and traders in the production areas due to its high market demand.

In Nueva Ecija, onion production is a high-risk venture due to the crop's vulnerability to inclement weather, pest, and diseases. Farmers must provide adequate inputs and timely field operations to ensure production and productivity, and to reduce losses. Land preparation and transplanting should be accomplished while the soil moisture is favorable for it. Timely application of fungicide to reduce diseases caused by fungi after heavy rain and pesticide to ensure protection from pest infestation is also needed. With this, the availability of power and type of power source are important to ensure profit.

Using a significant amount of power and appropriate technology increases farm productivity; thus, farm power is one of the important inputs to meet the desired production level. Animal and human power are limited, thereby restraining the use of tools and equipment. The use of mechanical power could provide the needed power but with additional cost (Indian Agricultural Statistics Research Institute, 2006).

With the general trend of diminishing agricultural labor force due to increasing urban migration and advancing age of heads of farming households, the use of machines to increase labor productivity and reduce drudgery has been recognized to be an essential alternative input of production. It allows timelier farm operation and a more precise application of inputs. It also maintains quality and reduces postharvest losses. Additionally, it reduces drudgery by significantly reducing working time and increasing safety and comfort of the working environment (Dela Cruz & Bobier, 2013).

According to Bello (2012), three indicators of agricultural mechanization includes level of mechanization, mechanization index, and degree of mechanization. Rodulfo et al. (1998) stated that mechanization is characterized into three levels: low, fair, and high. A low mechanization level means that manual power utilization exceeds 33%, while fair means that animal power use ranges from 34% to 100%. A high-level means that mechanical power utilization ranges from 67% to 100%.

Upon the enactment of the Agricultural and Fisheries Mechanization Act Law in 2013, continuous massive mechanization and modernization programs in agriculture are implemented. However, vital information and benchmark studies needed by these programs and projects are lacking. For major crops such as rice and corn, these data have been provided and updated. However, for other crops including onion, information is still lacking or obsolete.

With the aid of providing these important data for the planning, technology development, and implementation of mechanization program for onion, studies assessing the level of mechanization of onion production in major production areas of Nueva Ecija were conducted. Thus, this paper presents the result of the assessment of mechanization level of onion production in Nueva Ecija.

The general objective of this study is to assess the level of mechanization of different field operations of onion production system in Nueva Ecija. Specifically, it aimed to:

a. determine the current situation of onion production in five (5) major onion producing municipalities of Nueva Ecija;
b. assess the level of human-powered, draft-powered, and mechanically powered mechanization technology used in onion production;
c. analyze the mechanization index and land productivity of onion production;
d. determine the possible hindrances of mechanizing onion production in Nueva Ecija; and
e. provide recommendations relative to the mechanization of onion production.

Materials and Methods

Study Areas

The five areas covered by the study are the municipalities of Bongabon, Gabaldon, Laur, Talavera, and Rizal. These municipalities are the major onion-producing municipalities in Nueva Ecija. Talavera is a first-class municipality; Bongabon and Rizal are second-class municipalities, while Laur and Gabaldon are third-class municipalities.

Data Collection and Sampling

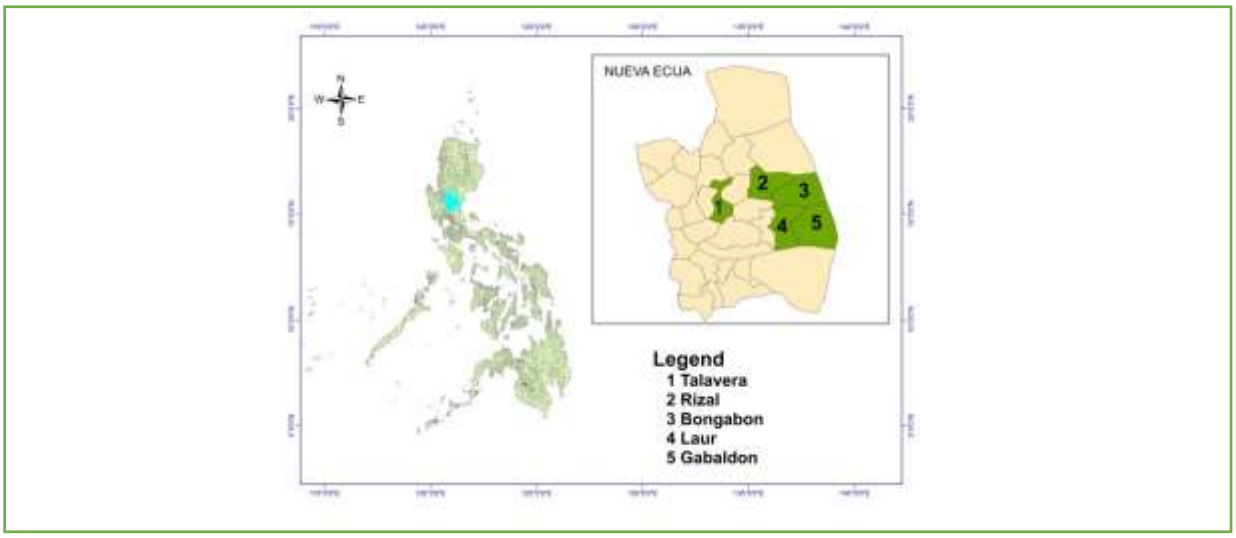
Data were gathered through face-to-face interviews of onion farmers and data available in the government offices such as in the Municipal Agriculture Office (MAO). The total number of respondents per municipality/barangay depended on the total number of onion farmers per municipality and not by the province. Each study area was treated as a separate study to not affect each other according to the number of respondents, mechanization index, and others. However, some factors were made similar, such as conceptual framework, survey questionnaire, group ranges, formulas, and others to level out data gathered for analysis and interpretation of results.

For each study site, the total number of onion farmers (population) gathered through the Municipal Agricultural Office (MAO) was used to compute the sample size. The number of respondents per barangay was dependent on the percent share of the number of onion farmers of that barangay to the total number of onion farmers in the municipality. Respondents were further categorized into four (4) groups depending on area planted, 0.1–0.7 ha, 0.8–1.4 ha, 1.5–2.1 ha, and 2.2–above. Stratified sampling was used as a sampling method. The formula used in computing the sample size is where z = Z-score, N = population size, Pv = Percent value, and Me = margin of error.

The survey instrument used by Gavino et al. (2006) was modified and used to fit the objectives of the study. Revisions were made to the survey instrument based on the results of the pre-test conducted.

Figure 1

Location Map of the Five (5) Study Areas



Data Analysis

Results of the survey were tabulated and analyzed to determine the following information:

a. Current situation of onion production in the area;
b. Projections (e.g., population, agricultural population, etc.);
c. Mechanization and energy input in the different field operations in onion production system;
d. Mechanization index; and
e. Labor and land productivity.

The mechanization level, mechanization index, and labor productivity are computed using the following formula:

where EH, EM, and EA are energy from human, mechanical, and draft-animal, respectively.

where Y is yield and A is area.

Data were analyzed using frequency analysis and subjected to correlation test using SPSS to determine the correlation coefficient. Several questions included in the survey questionnaire were aimed to answer the possible hindrances of agricultural mechanization for onion production.

Results and Discussion

Agricultural Situation

Production Area

The agricultural production area results show that the largest area among the entire study area is utilized for rice followed by onion (Table 1). It also shows that Bongabon has the highest area utilized for onion production, while Laur has the lowest. Figure 2 also displays the top areas utilized for onion production in Nueva Ecija.

Table 1

Production Area in Five (5) Municipalities of Nueva Ecija, Philippines

Study Area	Production Area, ha			
	Rice	Onion	Corn	Others
Laur	3,406.5	411.9	110.0	207.7
Gabaldon	1,886.0	1,587.0	109.5	393.5
Bongabon	3,711.0	2,695.5	675.0	388.9
Rizal	7,494.0	1,107.0	666.0	1,158
Talavera	8,817.0	520.0	--	728.7

Field Activities and Operations in Onion Production

Major field activities undertaken include land preparation, crop establishment, crop care and maintenance, and harvest-postharvest operation. These activities could be divided into sub field operations (Table 2). Land preparation starts during plowing up to plotting when the field is readied for planting. Crop

establishment includes seed sowing to pulling of seedlings and transplanting to the field. Crop care and maintenance operations are done during vegetative stage to before harvest.

Figure 2

Onion Production Area Map of Nueva Ecija

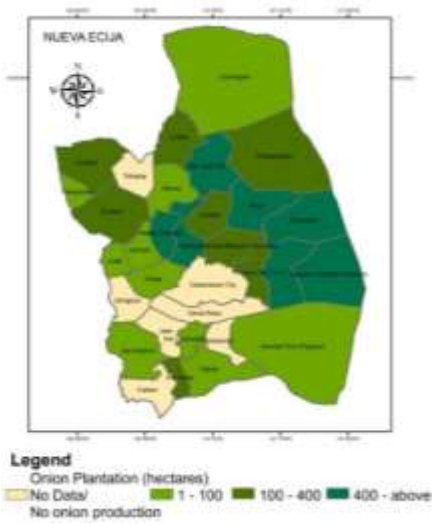


Table 2

Field Operations Undertaken during Onion Production

Major Field Activity	Sub Field Operation
Land Preparation (LP)	Plowing
	First Harrowing
	Second Harrowing
	Levelling
	Plotting
Crop Establishment (CEs)	Seed Sowing
	Spraying
	Fertilizer App
	Irrigation
	Pulling & Bundling of Seedlings
	Transplanting
Crop Care and Maintenance (CCM)	Fertilizer App
	Spraying
	Weeding
	Irrigation
Harvest/Postharvest (H/Ph)	Pulling of Onions
	Cutting of Stem
	Cleaning
	Bagging
	Hauling

Machinery, Tools, and Other Equipment Inventory

The agricultural machinery and equipment inventory shows that hand tractors, water pumps, and sprayers are very common machines owned by farmers. Four-wheel tractors are not that significant in numbers, with Rizal having the highest with 70 units, followed by Talavera with 67 units, Bongabon with 58, Laur with 45 units, and Gabaldon with the lowest with only 27 units (see Table 3). Since rice and onion are the top two crops planted in the study areas (and the third is corn), owning common machinery used for the production of these crops are the main focused of the farmers.

With the introduction of rice transplanters and combine harvesters and its societal acceptance, rice harvesting has started to become highly mechanized. Commonly, owners tend to buy 35–50 hp tractors for pulling the unit and this would give additional power available for production operations to other crops, like onion.

Table 3

Inventory of Four Wheel Tractors

Study Area	Units of Four-Wheel Tractors
Laur	45
Gabaldon	27
Bongabon	58
Talavera	67*
Rizal	70

Note: From "PHilMech Annual Report 2014," by the Philippine Center for Postharvest Development and Mechanization. (https://www.philmech.gov.ph/assets/publication/Annual%20Report/PHilMech%20Annual%20Report%202014.pdf)

Available Power

Table 4 shows the power available for onion production in the five study areas. Available power for onion production results show further that Rizal has the highest available power for onion production with 9.71 hp per ha. Only Talavera has power available of less than 1hp per ha with only 0.60 hp per ha. On the average, 3.25 hp per ha is available power for onion production.

Table 4

Available Power for Onion Production

Study Area	Available Power per Power Source, kW/ha			
	Human Power	Animal Power	Mechanical Power	Total
Laur	0.09	0.51	1.02	2.51
Gabaldon	0.11	0.05	2.16	2.32
Bongabon	0.081	0.352	2.941	1.125
Talavera	0.08	0.06	0.46	0.60
Rizal	0.10	1.11	8.50	9.71
Average	0.92	0.42	3.02	3.25

Level of Mechanization of Onion Production

Production Area Demographic Profile of Respondents

A total of 1,418 respondents from 88 barangays of the five study areas were interviewed. With the highest number of onion farmers, Bongabon had the highest number of respondents with 354 farmers from its 21 barangays. Gabaldon followed with 344 farmers; however, it had the least number of barangays covered with only 13 barangays. A total of 236, 232, and 252 respondents were interviewed from 23, 16, and 15 barangays of Talavera, Laur, and Rizal, respectively. Table 5 further shows that majority of the area cultivated are small with 527 farmers or 37.2% of the total number of farmers cultivating 0.1 ha to 0.7 ha (Figure 3). This was followed by farmers cultivating 0.8 ha to 1.4 ha with 33.7%.

The cultivated areas of respondents are small due to partition of siblings, high production cost, and very high risk of loss. According to the Philippine Statistics Authority (2017), the cost per hectare of production is around 148,212 for red onion and 102,590 for multipliers. It is also high risk to losses and damages during bad weather and attacks of pests, such as twister and army worms.

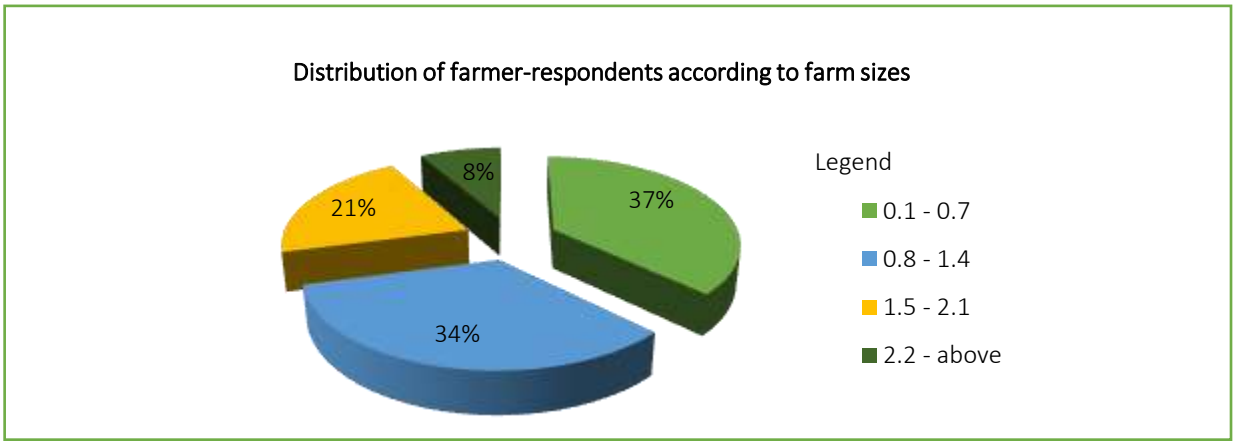
Table 5

Number of Farmer-Respondents per Farm Size

Study Area	Number of farmer-respondents				
	0.1–0.7ha	0.8–1.4ha	1.5–2.1ha	≥2.2 ha	Total
Laur	120	81	24	7	232
Gabaldon	116	101	92	35	344
Bongabon	181	140	27	6	354
Talavera	59	59	59	59	236
Rizal	51	96	93	11	252
Total	527	478	295	118	1,418

Figure 3

Distribution of Farmer-Respondents according to Farm Size



Majority of the respondents own the farms they manage with an average of 58.1%. Share cropping or the colloquial term of *kasama* comes second with 45% for onion and rice farmers. Share croppers are non-

owners of land but they provide the needed management and labor/manpower for field operations, while the land owners provide funding, equipment, and supplies.

Cropping patterns are different in each study area. Table 6 shows that the area cultivated most is used for vegetable production (including onion). Onion-Rice pattern is around 28.9% averages. The respondents hinted that cropping pattern is affected by availability of irrigation water. Rice and rainy season vegetables are planted during the wet season, while onion and dry season vegetables/fruits are cultivated during the dry spell.

Irrigation source results show that most farmer-respondents pump water for irrigation. Water comes from deep wells, rivers, small water reservoir, as well as irrigation canals where water is shallow and/or stagnant.

Table 6

Characteristics of Cultivated Land of Farmer-Respondents

Particulars	Farmer-Respondents, %					Average
	Laur	Gabaldon	Bongabn	Talavera	Rizal	
Tenurial Status						
Owned	80.2	31.0	61.6	67.4	50.4	58.1
Lease hold	2.6	26.0	0.5	5.5	12.3	9.4
Pawned-in	3.0	11.0	15.0	3.4	17.9	10.0
Share Cropping	14.2	32.0	22.9	23.7	19.4	22.5
Cropping Pattern						
Onion-Rice	18.5	31.1	19.5	14.0	61.5	28.9
Onion-Veg.	74.6	51.2	38.1	84.3	13.1	52.3
Onion-Veg-rice	0.0	17.7	0.0	0.0	25.4	8.6
Onion-Onion	6.9	0.0	0.0	1.7	0.0	1.7
Onion-Corn	0.0	0.0	42.4	0.0	0.0	8.5
Irrigation Source						
Communal	35.8	0.0	18.9	0.0	0.0	10.9
Individual pump	54.3	70.9	76.6	78.0	91.7	74.3
NIS/RIS	10.3	8.1	4.5	22.0	0.4	9.1
Spring water/ Rainfed	0.0	21.0	0.0	0.0	7.9	5.7

Farm Machines, Equipment, and Farming Utilities Ownership

common tools use for daily farm work such as cutting, weeding, and forage harvesting. The shovel is also a common tool used in many works such as ridging and plotting. It is a needed tool during irrigation for clearing and closing ways for water flow. Data showed that almost all respondents in Bongabon have at least 2 units each or 92.75% of these four common tools. Gabaldon and Laur areas have averages of 82% and 84%, respectively. Hoe, rake, *dulos* or hand trowel/hand shovel, and watering can are other tools used by farmer respondents.

Table 7 shows the three different power sources per strata. Hand tractor ownership is highest among the three major power sources except in areas in the 0.1–0.7 ha range. Draft animal ownership follows which is the highest in the first strata (0.1–0.7 ha). Ownership of hand tractors increases as cultivated area increases. Furthermore, about 5.07% own more than one unit. Interviews revealed that borrowing and leasing to other farmers are still practiced because neighboring farm owners are relatives or friends.

As for the ownership of four-wheel tractors, farmer-respondents in the fourth strata (2.2 ha and above) have the highest ownership with 29.5%, while the first strata (0.1–0.7 ha) has the lowest at 1.4%. Table 7 also shows that Talavera did not have any respondent who owns a four-wheel tractor.

On the other hand, data does show an increased or decreased ownership of draft animal as cultivated area increases. Across all areas and strata, about 38.3% own a draft animal, which is commonly a carabao. Again, borrowing and leasing to a relative or neighbor are common practices. Animal-drawn plows, harrows, and planks are common with about 30.7% having these implements. This supports the earlier data that draft animals (38.3%) are still owned by farmers.

Table 7

Ownership of Power Sources

Area/Type	Farmer-Respondents, %				
	All farm sizes	0.1–0.7ha	0.8–1.4ha	1.5–2.1ha	≥2.2
Hand Tractor	54.8	39.2	59.6	69.6	84.1
4W Tractor	4.2	1.4	3.7	10.6	29.5
Animal	38.3	43.2	44.3	41.1	59.3

Because onion is grown during the dry season, irrigation water is mostly pumped even from irrigation canals. As shown in Table 8, the number of pumps owned by farmers increases with the area cultivated. Borrowing and leasing are common to co-farmers. Table 8 further shows the ownership of three (3) different sprayers. In some areas, power and electric sprayers are now being used, but knapsack sprayers are more common. In Talavera, only knapsack sprayers are being utilized, while electrical sprayers are commonly used in Bongabon and Rizal.

Table 8

Water Pump and Sprayer Ownership

Area/Type	Farmer-Respondents, %				
	All farm sizes	0.1–0.7ha	0.8–1.4ha	1.5–2.1ha	≥2.2
Water Pump	56.1	44.3	57.1	66.7	82.4
Power Sprayer	27.7	19.0	28.0	37.3	57.1
E. Sprayer	23.2	21.3	23.5	29.6	19.1
Knapsack Sprayer	72.1	85.0	77.7	75.3	81.4

Source of Power and Labor in Farm Operation

Respondents stated that the economy, farm size, and power availability dictate the equipment that would be used for land preparation. Plowing is mostly done by hand tractors (53.4%), followed by the use of animals with 30.9%. No respondent does manual plowing. Harrowing is accomplished by the majority using hand tractors with about 87.4%. Only 9% and 3.5% stated that they use animal and four-wheel tractors in harrowing, respectively. Talavera and Rizal data show that 100% and 95.5% of respondents, respectively, use hand tractor in harrowing. Furthermore, about 57.8% of respondents stated that leveling is done using animals, followed by hand tractor with 36.5%, and manual at 11.4%. No respondent uses the four-wheel tractor in leveling and plotting. Plotting is done with an animal at 49.3%, manually at 36.7%, and with hand tractors at 14%. Some respondents stated that even though they use animals and hand tractors for levelling and plotting, they still do the finishing/finalizing manually.

Crop establishment and harvesting are 100% accomplished manually using hand tools. On the other hand, 82.9% of the respondents said they pump irrigation water from rivers, wells, small impounded water, and irrigation canals, while 17.1% said they get water from free-flowing sources like springs and irrigation canals.

Weeding is done manually (99.8%), while spraying of pesticides is done with the aid of manually operated knapsack sprayer (65.2%) and power/e-sprayer (34.8%). Respondents stated that using the knapsack sprayer is economical, while other types of sprayers are uncommon in their areas.

Fertilizer application is mostly done with manual broadcasting (87.5%), while some farmers who mostly use liquid fertilizer use the sprayers (12.5%).

Hauling is accomplished using animal carts and hand tractor trailers. In some instances, onions in bags/*buriki* are carried manually to the assembly area. About 67.3% use machines for hauling and only 32.7% use animals.

Mechanization Technology Utilized by Farmers with Farm Area of 0.1 to 0.7 ha

For the farm areas with 0.1–0.7 ha, human power (P_H) utilized is around 21.75 kW/ha total or 1.09 kW/ha per field operation, animal power (P_A) at 5.31kW/ha or 0.27kW/ha per field operation, and mechanical power (P_M) at 49.08 kW/ha or 2.45 kW/ha per field operation (Table 9). Land preparation has the highest utilization for P_M with 26.08 kW/ha. From crop establishment to postharvest, input for P_M is attributed only to the use of pumps for irrigation (19.98 kW/ha), power and electric sprayers for pesticide/liquid fertilizer application, and tractors for hauling. The total power utilized for the first strata (0.1–0.7 ha) is 76.14 kW/ha or 3.81 kW/ha average per field operation.

Mechanization Technology Utilized by Farmers with Farm Area of 0.8 to 1.4 ha

Power utilized for the second strata (0.8–1.4 ha) is similar to the first strata (0.1–0.7ha) in that major P_M contribution only comes from land preparation with 21.30 kW/ha and 8.09 kW/ha from pump irrigation. The total power utilized for the second strata is 52.24 kW/ha or 2.61 kW/ha average per field operation, where 35.05 kW/ha is P_M.

Mechanization Technology Utilized by Farmers with Farm Area of 1.5 to 2.1 ha

Land preparation again has the highest P_M utilization for areas 1.5–2.1 ha. This strata utilizes an average of 0.69 kW/ha P_H, 0.04 kW/ha P_A, and 1.42kW/ha P_M with a total of 2.15 kW/ha for every field operation. Total power utilized for this strata is 42.97 kW/ha.

Mechanization Technology Utilized by Farmers with Farm Area of ≥ 2.2ha

Like the other three strata, land preparation has the highest P_M utilization for areas ≥ 2.2ha. For this strata, P_H utilized is around 0.62 kW/ha, 0.02 kW/ha from P_A, and 1.82 kW/ha from P_M for a total average of 2.45 kW/ha. Total power utilized is 49.10 kW/ha.

Table 9

Mechanization Technology and Level of Mechanization

Field Operation	Total Power Utilized (kW/ha)				Average Power per Sub-Field Operation (kW/ha)*				Level of Mechanization
	P_H	P_A	P_M	Total	P_H	P_A	P_M	Total	
					0.1–0.7ha				
LP	1.30	4.23	26.08	31.62	0.26	0.85	5.22	6.32	High
CEs	6.48	0.00	9.23	15.70	1.08	0.00	1.54	2.62	Low
CCM	4.69	0.00	11.59	16.28	1.17	0.00	2.90	4.07	High
H/Ph	9.28	1.07	2.18	12.53	1.86	0.21	0.44	2.51	Low
Sum/ Average*	21.75	5.31	49.08	76.14	1.09	0.27	2.45	3.81	
					0.8–1.5ha				
LP	0.54	1.28	21.30	23.12	0.11	0.26	4.26	4.62	High
CEs	5.02	0.00	4.25	9.27	0.84	0.00	0.71	1.55	Low
CCM	2.74	0.00	5.56	8.31	0.69	0.00	1.39	2.08	High
H/Ph	7.36	0.25	3.93	11.54	1.47	0.05	0.79	2.31	Low
Sum/ Average*	15.67	1.53	35.05	52.24	0.78	0.08	1.75	2.61	
					1.6–2.2ha				
LP	0.39	0.71	19.88	20.99	0.08	0.14	3.98	4.20	High
CEs	4.59	0.00	2.30	6.89	0.76	0.00	0.38	1.15	Low
CCM	2.30	0.00	3.72	6.02	0.58	0.00	0.93	1.51	Low
H/Ph	6.50	0.17	2.39	9.06	1.30	0.03	0.48	1.81	Low
Sum/ Average*	13.78	0.89	28.30	42.97	0.69	0.04	1.42	2.15	
					> 2.2ha				
LP	0.37	0.41	26.77	27.55	0.07	0.08	5.35	5.51	High
CEs	4.20	0.00	1.93	6.13	0.70	0.00	0.32	1.02	Low
CCM	2.02	0.00	4.14	6.16	0.50	0.00	1.04	1.54	High
H/Ph	5.75	0.01	3.49	9.25	1.15	0.00	0.70	1.85	Low
Sum/ Average*	12.34	0.42	36.33	49.10	0.62	0.02	1.82	2.45	
					Across Strata				
LP	0.65	1.66	23.51	25.82	0.13	0.33	4.70	5.16	High
CEs	5.07	0.00	4.43	9.50	0.85	0.00	0.74	1.58	Low
CCM	2.94	0.00	6.26	9.19	0.73	0.00	1.56	2.30	Low
H/Ph	7.22	0.38	3.00	10.60	1.44	0.08	0.60	2.12	Low
Sum/ Average*	15.88	2.04	37.19	55.11	0.79	0.10	1.90	2.79	

* - Averages are computed across sub field operation not per major activity
P_H – Human Power, P_A – Animal Power, P_M – Mechanical Power

Mechanization Technology Utilized in Onion Production

Results show that the first strata (0.1–0.7 ha) has the highest power utilized per hectare. This is true since the first strata is characterized by farmers with small farm sizes and this may be due to farm size-to-

available power ratio. Accordingly, human and animal power utilization decrease as the area increases. The first strata (0.1–0.7 ha) has the highest utilization of P_H and P_A, while the fourth strata (> 2.2ha) has the lowest.

Land preparation contributes highly on mechanical power utilization; however, precarious operations are still done manually. Although the application of liquid fertilizer also contributes to mechanical power utilization, many farmers who use granular fertilizers still apply manually through broadcasting.

According to this study, around 0.79 kW/ha of P_H, 0.10 kW/ha of P_A, and 1.90 kW/ha P_M are utilized in field operations. A total of 55.11 kW/ha is utilized in onion production or 2.79 kW/ha per operation (Table 9). Land preparation is highly mechanized since 23.51 kW/ha out of 25.82 kW/ha or 91.6% of power came from mechanical aid.

On the other hand, crop establishment and crop maintenance have low mechanization levels with 57.6% and 33.2% P_H, respectively. This mainly due to human as the major source of power during seed sowing, pulling and bundling of seedlings, and weeding. Mechanical power is the main source of power only during irrigation operations for crop maintenance; that is why mechanization level almost reaches the threshold of highly mechanized with 66.8% P_M. Should there be a good water source for farmers such as free flowing water from canals and grounds or even rain, the use of mechanically powered pumps would be reduced.

Harvesting and postharvest operations are still lowly mechanized with 72.2% P_H. Only during hauling is mechanical power utilized. It is also observed that mechanical aid is utilized most rather than animal power.

Mechanization Index and Productivities in Onion Production

Mechanization Indices of the Different Field Operations in Farm Area 0.1–0.7 ha

Table 10 shows the mechanization indices (I_E) of different field operations in farm areas of 0.10.7 ha. Field operations are still accomplished without mechanical power and are mostly done manually. I_E in land preparation is still intermediate with only 0.688. Crop establishment has a low I_E of 0.133, while crop care has high I_E at 0.827 due only to the use of pumps for irrigation. Harvest/postharvest also has low I_E of 0.247 which is contributed only by hauling. The average I_E for this strata is 0.647.

Mechanization Indices of the Different Field Operations in Farm Area 0.8–1.4 ha

Table 10 further shows the I_E for farm areas 0.8–1.4 ha. Compared to the first strata (0.1–0.7 ha), I_E for plotting operation has increased which affects the total I_E for land preparation at 0.859. Increased I_E was also noted with the use of power and electrical sprayer by farmers. Average I_E for farm areas 0.8–1.4ha was computed 0.685.

Mechanization Indices of the Different Field Operations in Farm Area 1.5–2.1 ha

The mechanization indices show that land preparation still contributes the highest in I_E utilization (0.893) with plowing to harrowing average of 0.946 (Table 10). Crop establishment and harvesting still have low I_E with 0.15 and 0.21, respectively. Irrigation, spraying, and fertilizer application contribute to around 0.98 and 0.85, and 0.41 for crop care, resulting to 0.76 I_E. Weeding is at 0.00 since it is still done manually and only hauling operation utilizes mechanical energy during harvest/postharvest operations. Average I_E for this strata is 0.654.

Mechanization Indices of the Different Field Operations in Farm Area 2.2 and Above

Land preparation shows high I_E at 0.96. Plowing to harrowing has very high I_E at 0.99, while levelling and plotting are around 0.88 and 0.80, respectively. These show that land preparation is mostly done with the aid of machinery.

Similarly, with the other three strata, crop establishment and harvesting still have low I_E averaging only to 0.16 and 0.36, respectively. Irrigation, fertilizer application, and spraying during crop maintenance has very high I_E, with 0.99, 0.93, and 0.93, respectively, but weeding is still done manually. The indicated average I_E for areas 2.2ha and above is 0.872.

Table 10

Mechanization Indices in Onion Production in Nueva Ecija, Philippines

Field Operation	Total Energy Utilized (kW/ha)			Average Energy per Sub-Field Operation (kW/ha)*			Mechanization Index
	P_H	P_A	P_M	P_H	P_A	P_M	
			0.1–0.7ha				
LP	8.65	27.59	80.09	1.73	5.52	16.02	0.688
CEs	49.54	0.00	7.62	8.26	0.00	1.27	0.133
CCM	41.80	0.00	199.83	10.45	0.00	49.96	0.827
H/Ph	32.87	3.06	11.78	6.57	0.61	2.36	0.247
Sum/ Average*	132.86	30.65	299.31	6.75	1.53	14.97	0.647
			0.8–1.5ha				
LP	6.18	13.40	119.28	1.24	2.68	23.86	0.859
CEs	42.10	0.00	10.14	7.02	0.00	1.69	0.194
CCM	53.52	0.00	200.07	13.38	0.00	50.02	0.789
H/Ph	42.60	4.20	23.55	8.52	0.84	4.71	0.335
Sum/ Average*	144.39	17.60	353.03	7.22	0.88	17.65	0.685
			1.6–2.2ha				
LP	5.00	10.11	126.16	1.00	2.02	25.23	0.893
CEs	55.64	0.00	9.45	9.27	0.00	1.58	0.145
CCM	49.70	0.00	154.04	12.43	0.00	38.51	0.756
H/Ph	38.11	2.01	13.29	7.62	0.40	2.66	0.249
Sum/ Average*	148.45	12.13	302.93	7.42	0.61	15.15	0.654
			> 2.2ha				
LP	7.42	6.13	297.68	1.48	1.23	59.54	0.956
CEs	47.08	0.00	8.90	7.85	0.00	1.48	0.159
CCM	55.84	0.00	708.83	13.96	0.00	177.21	0.927
H/Ph	35.26	0.26	24.12	7.05	0.05	4.82	0.404
Sum/ Average*	145.60	6.40	1039.53	7.28	0.32	51.98	0.872
			Across Strata				
LP	6.81	14.31	155.80	1.36	2.86	31.16	0.849
CEs	48.59	0.00	9.03	8.10	0.00	1.50	0.158
CCM	50.22	0.00	315.69	12.55	0.00	78.92	0.825
H/Ph	37.21	2.38	18.18	7.44	0.48	3.64	0.309
Sum/ Average*	142.83	16.69	498.70	7.17	0.83	24.94	0.715

* - Averages are computed across sub field operation not per major activity
P_H – Human Power, P_A – Animal Power, P_M – Mechanical Power

Mechanization Index of Onion Production

Mechanization Index shows that areas 2.2 and above has the highest mechanization index (0.872) compared to other strata. This could mean that human and animal power may not be enough or available to finish field operations on time and that economy using mechanical aid is comparable to other power sources. While the energy used from draft animal was highest in 0.1–07 ha farm area and showed a decrease as area cultivated increases (Table 9). The mechanization index for onion production computed is 0.715 or 71.5% of the energy utilized coming from mechanical aid.

The mechanization index for land preparation (LP) shows a high level at 0.849. Land preparation is accomplished mostly with the aid of mechanical power. At 2.2ha and above, plotting and levelling have reach 0.80 I_E or around 0.1 higher than the three other strata.

Crop establishment (CEs) and harvesting operations show that the mechanization index are low at 0.158 and 0.309, respectively. Seed sowing, pulling/bundling of seedlings, and transplanting are 100% done manually. Pulling of onions, cutting of stem and roots, cleaning and bagging are also manually done.

Although the mechanization index during crop care and maintenance (CCM) is about 0.825, some operations are still accomplished manually like weeding and fertilizer application. Spraying is still done manually through back-carried sprayers. At the fourth strata (> 2.2ha), weeding has 0.11 I_E which means some farmers utilize machinery to do weeding operations, while other strata show 0.00 I_E.

Harvest and Postharvest operations (H/Ph) are done manually with the aid of small hand tools. Only hauling operations utilize mechanical power. Respondents cited that further cleaning, sorting, and assembly (short term storage) are done in the traders' level. Respondents know that these are done manually and no machinery or equipment are used for these postharvest operations.

Land and Labor Productivity

Labor productivity in onion production shows that the utilization of draft-animal increases the labor productivity as area cultivated increases (Figure 4). Human and mechanical utilization have no significant difference throughout the four strata. Labor productivity increases as land holding increases (Table 11). The labor productivity of onion production is 1.378.

Land productivity was computed at 9.06 MT/ha average across the five study areas which is not significantly different from the data provided by the PSA with around 8.99 MT/ha for Nueva Ecija onion production.

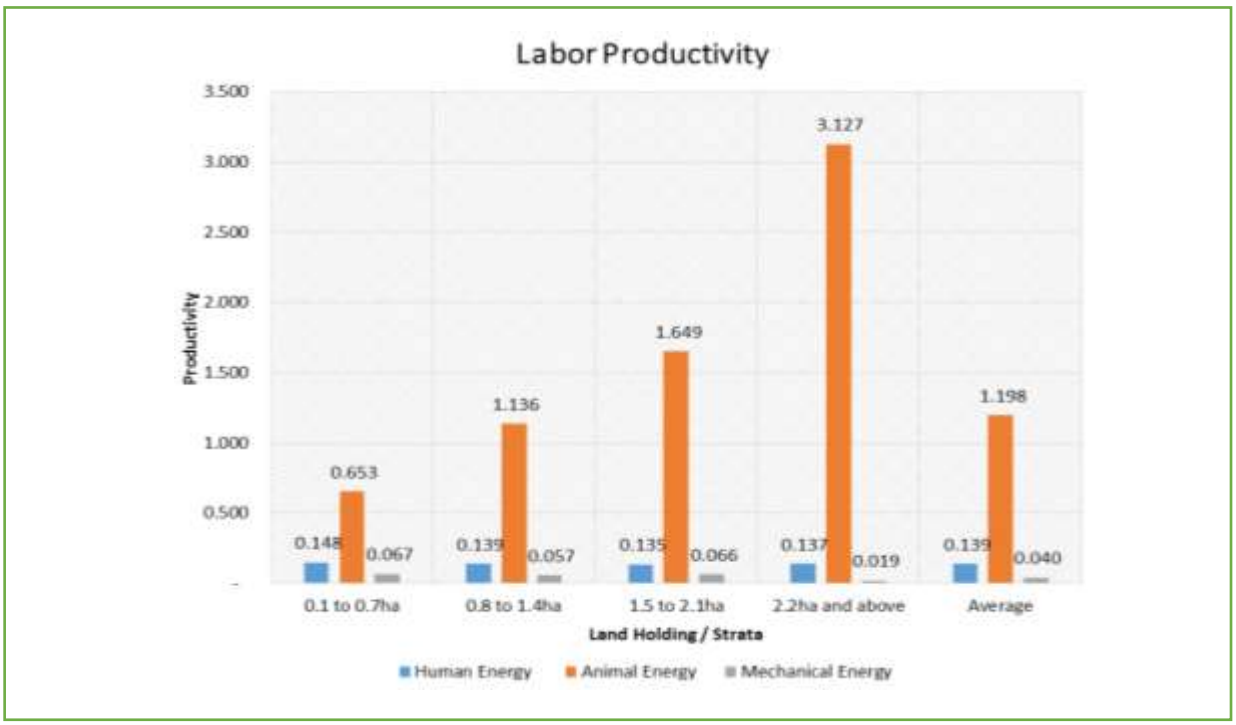
Table 11

Labor Productivity in Onion Production

Strata (ha)	Labor Productivity
0.1 to 0.7ha	0.868
0.8 to 1.4ha	1.331
1.5 to 2.1ha	1.850
2.2 ha and above	3.284
Average	1.378

Figure 4

Productivity of Different Power Sources in Onion Production



Problems, Constraints, and Hindrances of Agricultural Mechanization

Most of the respondents have a problem with hiring human labor during weeding, transplanting, and harvesting of onions. The insufficient human labor available due to simultaneous need to finish the work of each farmer may cause delay on the schedule of farm operations that can lead to reduction of profit.

Based on the result of surveys conducted, Table 12 shows the hindrances on mechanization of onion production in Nueva Ecija. The machines that are available in the market are expensive (72.15%), which are not affordable (73.45%) for farmers who have small farm sizes (64.41%). They prefer to borrow or rent machines to perform their farm operations.

Approximately half of the respondents claimed that they lack knowledge on farm machineries (51.79%) and are unaware of the machines suitable for onion production, considering the farm topography (44.01%). Moreover, the farmers stated that they are unaware of the available machines (54.65%) and they don't know how to operate farm machines (32.11%), which makes the work harder (33.87%) instead of reducing their drudgery. This is because of the inadequate support service (59.55%) from the private and government sectors which can be solved through services such as, but not limited to, information dissemination or exhibits and trainings on farm machine operation.

Table 12

Hindrances of Agricultural Mechanization for Onion Production in Nueva Ecija

Possible Hindrances	Respondents, %
Machines are expensive	72.15
Inadequate support services	59.55
Small farm size	64.41
Lack of knowledge on farm machines	51.79
Machines are unaffordable	73.45
Unaware of the availability of suitable machine	54.65
Don't know how to operate a machine	32.11
Makes the work of farmer harder	33.87
Farm machine cause more losses	26.80
Places pressure on fragile natural resources	21.76
Machine is not appropriate for my farm/crop	44.01
Displaces human labor	13.50

Recommended Mechanization Strategy for Onion Production

Besides rice production, Nueva Ecija is one of the major producers of onion in the Philippines. Thus, farm machineries used by farmers are mainly for rice but can be utilized when planting onion. Onion farmers in the province use machineries during land preparation, spraying, and hauling but do manual labor for the other farm operations like seedling preparation, transplanting, weeding, and harvesting.

Based on the results of the study, some factors like the non-availability of machineries for onion production are the hindrances to mechanization. This deficiency forces the farmers to hire and do manual labor on most farm operations; however, they have a problem on sufficiency of manpower during simultaneous hiring of laborers.

Consequently, strategies to surpass the problems and hindrances for mechanization of onion production in the province are suggested:

1. Farmers must acclimatize themselves to farm mechanization.

2. Onion farmers should form community organizations that will acquire farm machineries for the production of onions.

3. Private agencies and government sectors must assess the growing needs of the local farmers to provide financial assistance, loans, and subsidies as well as seminars, trainings, field demonstration and exhibits to encourage and educate farmers in investing on farm machineries.

4. Research institutions and local manufacturers should venture on design and fabrication of agricultural machineries for harvesting, weeding, and transplanting operations in onion production.

Conclusion and Recommendation

Conclusion

The following conclusions are established based on the assessment conducted on the level of mechanization of different field operations of onion production system in Nueva Ecija.

1. The five major onion producing municipalities in Nueva Ecija namely Laur, Gabaldon, Bongabon, Rizal, and Talavera has a production area of 411.9ha, 1,587ha, 2,695.5ha, 1,107ha, and 520ha, respectively with a total of 6,321.4ha. An average of 3.25hp per ha of power is available for onion production.
2. The level of mechanization at 0.79kW/ha of P_H, 0.10kW/ha of P_A and 1.90kW/ha P_M are utilized in field operations. A total of 55.11kW/ha is utilized in onion production or 2.79kW/ha per operation.
3. The mechanization index of the onion production in Nueva Ecija is 0.715 or 71.5%, labor productivity at 1.375 kW/ha, and land productivity at 9.06 MT/ha.
4. Major hindrances on mechanization of onion production in Nueva Ecija is the expensiveness of machines that are available in the market which is unaffordable to farmers who have small farm sizes. Thus, they prefer to borrow or rent machines to perform their farm operations.
5. Land preparation, spraying, and irrigation are among the field operation that is mechanized in the province. Whereas, transplanting, crop establishment, and harvesting is done manually. This situation requires the farmers to hire laborers when needed.

Recommendation

Based on the results of the study, the following are recommended to increase the level of mechanization in the province.

1. Collaboration between the government and onion farmers to form community organizations. This will enable the stakeholders to easily access the farmers on provision of farm machineries, services, trainings, seminars, and other programs that will increase the level of mechanization of onion production in the province.

2. The government must provide financial assistance to encourage the onion farmers who are willing to invest on farm machineries.

3. Research institutions and local manufacturers should venture on design and fabrication of agricultural machineries for harvesting, weeding, transplanting operations in onion production.

4. This study can provide additional information about onion production that will serve as a tool for stakeholders to improve mechanization of onion production in Nueva Ecija.

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