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Review of Increasing Rice Productivity: Jajar Legowo Planting System, Productivity, Opportunities and Development Strategies in Rice Fields

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Abstract
Rice (Oryza sativa L.) is one of the strategic foodcrop commodities in Indonesia and rice production is very important in the context of sustaining national food security with the target of achieving food (rice) self-sufficiency. The purpose of this article is to review efforts to increase rice productivity through the Jajar Legowo planting system, opportunities and development strategies in rice fields to support Indonesia's food security. The jajar legowo planting system provides higher rice productivity and can increase rice productivity between 12.26-33.07% compared to the tegel planting system. Economically, the Jajar Legowo planting system is profitable and worthy of being developed on a wider scale. The strategy for developing the Jajar Legowo planting system through the S-O Strategy, including carrying out action programs with farmer groups implementing the Jajar Legowo planting system technology, being able to increase rice production and farmer income. Increase human resource capacity, perception and institutions with education and training. W-O strategy includes counseling using the Jajar Legowo planting system technology which can increase farmers' production and income. Motivate farmer groups to plant rice using the Jajar Legowo planting system using an agribusiness approach and the use of planting equipment/transplanters) through a partnership pattern. The S-T strategy includes optimizing agricultural land and implementing an integrated pest control system. W-T strategy includes, among other things, using varieties that are resistant to pests and diseases and tolerant to the environment. Training farmers/farmer groups are able to become pest observers on their own land.

Key Words: *Jajar Legowo Planting System, Rice productivity, Opportunities and Development Strategies*

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the strategic foodcrop commodities in Indonesia and rice farming is still the backbone of the rural economy. Procurement of domestic rice production is very important in the context of sustaining national food security with the target of achieving food (rice) self-sufficiency. It is the majorcrop for small farms. Rice is also the food stapleand domestic demand for rice is very large. The Government of Indonesia through the Ministry of Agriculture continues to increase riceproduction and productivity in order to meet theincreasing domestic needs which in line with anincrease in human population (Sumarno et al., 2020). However, riceproduction in Indonesia is leveling off, so thatseveral efforts are needed to increase theproductivity. Overcoming the decrease amount of rice production, the application of technology in agricultural development is absolutely necessary, because it is one of main requirements of agricultural development (Deichman et al., 2016). Without technology, agricultural development will slow down so that people's need for food can't be met because according to Malthus' theory that population growth will increase according to arithmetic (Okosodo, 2016).

The application of rice farming technology at the farmer level is still not

optimal, including planting methods that do not comply with technological recommendations or still using a tile planting system (Jumakir and Endrizal, 2017). The planting system that is widely used by farmers is the tile system with a planting distance of 25 cm x 25 cm or 20 cm x 20 cm. This planting system can save seeds, is easy to maintain, production can be increased to 6-7 t/ha. Along with technological developments, the Agricultural Research and Development Agency has produced technology using the Jajar Legowo planting system. This system can increase production by 1–1.5 t/ha from the tile system. This is because the plant population can be increased by up to 30 percent. The results of the study by the Agricultural Research and Development Agency produced a super productive jajar legowo system that could reach 8–9 t/ha (Witjaksono, 2018).

One effort to increase rice production in rice fields is using the Jajar Legowo planting system with an integrated crop management approach. It is hoped that the Jajar Legowo planting system will increase rice production even higher. According to Erythrina and Zaini (2014), that the advantage of the jajar legowo planting method when compared with tiles is that the number of plants per unit area is greater so that production is higher and with alternating distances it causes more air circulation and sunlight to enter thereby reducing pests and diseases as well as easier fertilization and weeding. The use of plant spacing is basically to give plants the opportunity to grow well without experiencing a lot of competition in terms of taking water, nutrients and sunlight. Correct plant spacing is important in optimal use of sunlight for the photosynthesis process. With the right spacing, the plants will get a balanced growing space.

Several studies have found that the Jajar Legowo cropping system can significantly increase riceproduction and farmers' income. One study found that this system can increase production by 20% (Alamsyah et al., 2022 and Istiyanti, 2021), while another study found that this system can increase plant population and lowland riceproduction by 33.07% compared to the conventional system (Suweta et al., 2021 and Rawung et al., 2021). The purpose of this article is to review efforts to increase rice productivity through the Jajar Legowo planting system, opportunities and development strategies in rice fields to support Indonesia's food security.

JAJAR LEGOWO PLANTING SYSTEM

According to the Javanese language, the Legowo planting pattern comes from the words Lego which means wide and dowo or long. This planting method was first introduced by Mr. Legowo, head of the Banjarnegara Regency Agriculture Service, Central Java. Legowo is an engineering planting technique by adjusting the spacing between clumps and between rows, so that the rice clumps are compacted in the rows and widen the distance between the rows. In the two row legowo row system, all the rice clumps are in the rows at the edge of the plant. As a result, all the rice groves benefit from the border effect.

According to Abdulrachman et al., (2013), that the Legowo row planting system is a planting system that pays attention to rows of plants and is an alternating crop between two or more rows of rice plants and one empty row. The goal is that the plant population per unit area can be maintained and can even be increased.

In principle, the Jajar Legowo planting system is to increase the population by adjusting the planting distance. This planting system also manipulates the planting layout so that most of the plant clumps become edge plants. Rice plants located on the edge will get more sunlight, thereby producing higher grain with better quality. In the 2:1 row planting method, every two rows of plants are alternated with one empty row with twice the width of the row, but the planting distance in the row is narrowed to half the original planting distance.

It turns out that setting the planting system determines the quantity and quality of rice clumps, together with the population/number of clumps of plants per unit area has an effect on crop yields. However, several factors that influence the implementation of a planting distance by farmers in an area are: 1) availability of labor, 2) availability of seeds, 3) ease of operation in the field (availability/absence of aisles), 4)

counseling about planting distances, and 5) regional conditions (drainage, endemic golden snails, etc.). According to Makarim and Ikhwani (2012), that planting distances of various sizes ranging from tiles 20 x 20 cm, 25 x 25 cm, 27.5 x 27.5 cm, 30 x 30 cm, to patterns jajar legowo with various variations, namely legowo 2:1, 4:1, 6:1 and 8:1, each of which comes from the spacing of tiles.

Putra (2011), that the legowo planting distance of 30x20x10 cm can produce upland rice as much as 3.29 t/ha, while the lowest yield was obtained by using a tile planting distance (25 x 25 cm) of 2.22 t/ha. Ha. Using a planting distance of 30 x 30 cm significantly increases yields and yield components compared to planting distances of 20 x 20 cm and 25 x 25 cm. Several types of Jajar Legowo planting systems are 1). Jajar Legowo 2:1. Every two rows are interspersed with one empty row with a width twice the distance in the row. However, the planting distance in long rows is narrowed to half the planting distance in the row. 2). Jajar Legowo 3:1. Every three rows of rice plants are interspersed with one empty row with a width twice the distance in the row. The spacing of rice plants on the edge is double the spacing in the middle. 3). Jajar Legowo 4:1. Every four rows of rice plants are interspersed with one empty row with a width twice the distance in the row. And so on. The distance between the plants at the edge is half the distance between the plants in the middle.

Table 1. Minimum requirements for the amount of grain yield per hill for planting methods jajar legowo had higher results than tile

Planting system	Planting elements		Original planting distance	
		20 cm x 20 cm	25 cm x 25 cm	30 cm x 30 cm
Tile	Number of clumps/ha	250.000	160.000	111.111
	Standard results	1	1	1
	grain per hill			
Jajar legowo	Number of clumps/ha	250.000 x 4/3 = 333.333	160.000 x 4/3 = 213.333	111.111 X 4/3 = 148.148
2:1	Minimum yield ratio	3/4	3/4	3/4
	Grain per hill			
Jajar legowo	Number of clumps/ha	250.000 x 6/5 = 300.000	160.000 x 6/5 = 192.000	111.111 X 6/5 = 133.333
4:1 empty	Minimum yield ratio	5/6	5/6	5/6
	Grain per hill			
Jajar legowo	Number of clumps/ha	250.000 x 8/5 = 400.000	160.000 x 8/5 = 256.000	111.111 X 8/5 = 177.778
4:1 full	Minimum yield ratio	5/8	5/8	5/8
	grain per hill			

Source: Ikhwani et al., 2013

The principle of the Jajar Legowo planting system is to increase the number of plant populations by regulating plant spacing. We can find out the amount of increase in plant population by implementing the row legowo planting system using the formula: 100% X 1 / (1 + number of legowo). Thus, for each type of Jajar Legowo planting system, we can calculate the addition/increase in population as follows;

- Jajar legowo (2: 1) population increase is 100% x 1 (1 + 2) = 30.00%
- Jajar legowo (3: 1) population increase is 100% x 1 (1 + 3) = 25.00%

• Jajar legowo (4: 1) population increase is 100% x 1 (1 + 4) = 20.00%
• Jajar legowo (5 : 1) population increase is 100 % x 1 (1 + 5) = 16.60 %
• Jajar legowo (6 : 1) population increase is 100 % x 1 (1 + 6) = 14.29 %

The row legowo planting system is one of the components of Integrated Crop Management in lowland rice which, when compared to other planting systems, has the following advantages: 1) There is a wider open space between two groups of rows of plants which will increase sunlight entering each clump of rice plants thus increasing photosynthetic activity which has an impact on increasing plant productivity. 2) This row crop system makes it easier for farmers to manage their farming business, such as: supplementary fertilization, weeding, and implementation of pest and disease control (spraying). Besides that, it is also easier to control rat pests. 3) Increase the number of plants on both sides for each set of legowo, so that there is an opportunity to increase plant productivity due to an increase in population. 4) This row crop system also has the opportunity to develop a rice-fish (mina padi) or parlebek (combination of rice, fish and duck) production system. 5) Increase rice productivity by up to 10-15% (Abdulrachman et al., 2013).

The closer spacing could increase rice yields with higher resource usage efficiency. Next, the tile planting system(TPS) with 25 ×12.5 cm plant spacing could be modified into 25 ×12.5 × 50 cm in JPS. It can be explained that thenumber of 25 cm indicated the spacing between rows. The number of 12.5 cm was the spacing in rows (edge), while the number of 50 cm was an empty row (twice the width between rows). The jajar legowo planting system(JPS) is one of the planting systems in rice farming fields (Istiyanti, 2021). The legowo planting technique is an engineering planting method that compacts rice clumps in rows and increases the distance between rows by adjusting the spacing between rice clumps between rows. Rice's growth and yield are heavily influenced by its spacing arrangement. Using optimal spacing will facilitate the optimal utilization of solar radiation and nutrients by the growth of plant shoots and roots. Narrow plant spacing increases plant competition for the use of nutrients, air, and light, resulting in shading conditions, grain loss, and an increase in the production of leaves and other vegetative parts (Bhowmik et al., 2012). In addition, a healthy root system caused by adequate plant spacing will result in healthy plant growth; plants will be able to gain weight, grow taller, absorb more nutrients, and produce more grain.

INCREASING RICE PRODUCTIVITY WITH JAJAR LEGOWO PLANTING SYSTEM

Efforts to increase the production and productivity of irrigated lowland rice, tidal swamp rice, lowland swamp rice and upland rice have been carried out through Green Revolution technology. The Agricultural Research and Development Agency through the Food Crop Research Center and the Rice Crop Research Center (BB Padi) has succeeded in obtaining new superior varieties that have high yield potential, such as irrigated lowland rice (Inpari), swamp rice (Inpara) and upland rice (Inpago). Along with technological developments, apart from superior varieties, the Agricultural Research and Development Agency produces technology using the Jajar Legowo planting system (Abdulrachman et al., 2013).

The performance of the rice planting system in irrigated rice fields shows quite good growth in the legowo 4:1, jajar legowo 6:1 and tegel planting systems in the vegetative and generative phases. The results of the study show that the 4:1 Legowo planting system provides better productivity than the 6:1 Legowo and tile planting systems, respectively 7.68 t/ha, 7.15 t/ha and 6.56 t/ha. The implementation of the legowo system increases rice production by 1.12 t/ha compared to the tegel planting system. In the 4:1 Legowo planting system, the financial profit is IDR 7,618,500; the 6:1 Legowo planting system has a financial profit of IDR 6,650,000, while the tile system produces a profit of IDR 5,951,000. Economically, the 4:1 Legowo planting system is the most profitable with an additional profit of IDR 1,443,000 per ha and an R/C ratio of 2.42. This planting system is worthy of being developed on a wider scale (Jumakir et al., 2012). Furthermore, the results of Misran's

research (2014), show that the application of the Jajar Legowo planting system has a significant effect on the yield components of harvested dry grain, and can increase the yield of harvested dry grain by around 19.90-22%. Inpari 13 rice varieties in Mauk District, Tangerang Regency have more optimal growth and high productivity in the Jajar Legowo 2:1 planting system (6.57 tons/ha) compared to the Jajar Legowo 4:1 planting system (5.57 tons/ha). ha) and the tile system (5.09 tons/ha) (Giamerti and Yursak, 2013).

The results showed that the consistent application of the jajar legowo cropping system could significantly increase rice productivity in all varieties tested. The highest grain yield was achieved for the Jajar legowo planting system 2:1 (7.99 t ha-1) with an increase of 15.2% from the conventional system (control). The planting system that gives a higher R/C is the application of jajar legowo 2:1, then Jajar legowo 4:1 and the lowest is the conventional cropping system, respectively: 2.32 > 2.17 > 2.10. The 2:1 jajar legowo planting system provides the highest feasibility compared to other cropping systems (Pramono et al.,2023). The research result Utami et al., (2020), that there was an increase in the growth of rice plants on the organic rice field with the Jarwo 2: 1 cropping system by 33.3% compared to the Grid system. The measurement of growth increase is based on the variables of the number of tillers, productive tillers, and panicles. Providing spacing in every two rows in Jarwo 2:1 increased the sunlight intensity received by plants and improved the air circulation. The microagroclimatic conditions around the plants also allow the soil organic decomposition process to run well.

The jajar legowo planting system (JPS) of 2:1, 3:1, and 4:1 with a plant spacing of 25 × 12.5 × 50 cm could increase crop populations per hectare by 32%,15%, and 11.87%, respectively, compared to the tile planting system (TPS) with a plant spacing of 25 × 25 cm. The advantage of the JPS is that it could inhibit weed growth on the soil surface around rice clumps. Besides, increase in crop populations per hectare compared to the TPS. (Paiman et al., 2023). According to Abdulrachman *et al*.(2013), the JPS of 2:1 type with a spacing of 25 × 12.5 × 50 cm could increase rice yield by 9.63- 15.44% compared to the TPS. The rice canopy has an important role in capturing sunlight. The light intensity increase noticeably increases the leaves'orientation towards sunlight, therebyincreasing thecapacity of the photosynthesis (Tang *et al*., 2022). Furthermore, the results showed that the JPS can increase rice yield compared to the JPS. The JPS of the 2:1 type provided the best results on crop height, number of saplings, and grain yield per unit area (Megasari *et al*., 2021). **(**The insertion of rice clumps into edge crops in rows can increase the plant population per hectare. Rice crops in the edge rows still get a good microclimate so that they can produce optimally. The rice yield obtained in JPS of 4:1type is lower than JPS 2:1 type because the crop population per hectare is lower. The Application of JLS rice cultivation technology will increase productivity by 13.62%; income by 29.88%; efficiency by 18.90%; and JLS rice farming provides benefits for rice farmers by 8.53 (Anggraeni et al., 2023).

The selection of high-yielding varieties combined with the appropriate planting system had an important influence on achieving high rice yields. There was an interaction effect between the application of the planting system and the use of varieties on rice yields. The planting system of legowo 4:1 (20 cm–40 cm) × 10 cm obtained higher grain yield than the tile 20 cm× 20 cm for the three varieties tested (Mira 1, Inpari 32, and Inpari 34) in this study. The application of the legowo 4:1 (20 cm–40 cm) ×10 cm on the Mira 1 variety resulted in the highest grain yield of 5.65 t ha-1 or an increase of 5.6% compared to the tile 20 cm × 20 cm planting system. The Mira 1 rice variety using the planting system of legowo 4:1 (20 cm–40cm) × 10 cm was the best technology component for rice cultivation in this study (Purwanto et al., 2020). The results showed that the amount of acceptance of legowo rows was higher than tiles, amounting to 9,358.3 kg/ha or Rp 15,152,802.25 for the cropping pattern legowo row and 4,185.4 kg/ha or Rp 7,101,485 for the receipt of unhulled rice production in the tile cropping pattern, the difference in production revenue is 5,172.9 kg/Ha or Rp 23,277,901 and the R/C ratio value

of 1.53 for legowo rows and 1.49 for tiles (Ilham et al., 2021).

OPPORTUNITIES AND DEVELOPMENT STRATEGIES JAJAR LEGOWO PLANTING SYSTEM

Development Opportunities

The jajar legowo planting method has the opportunity to increase grain yields because apart from the population being higher than the tegel planting method, the planting orientation is also better in utilizing solar radiation. Apart from that, the increase in grain yield will be more obvious by selecting adaptive varieties in dense cropping conditions (Ikhwani et al., 2013).

The row legowo planting system makes all or most plants become edge plants. Edge plants will get more sunlight, better air circulation, and the plants will get more nutrients compared to the tile planting method. A higher population in the Jajar Legowo planting system provides the opportunity to get high yields. The presence of empty aisles in the legowo system makes plant maintenance easier; controlling weeds and fertilizing can be done more easily. Apart from having several benefits, the Jajar Legowo planting system also has several disadvantages, namely: 1) It requires more planting power and a longer planting time. 2) Requires more seeds as the population increases. 3) Usually, the empty areas between the rows of plants will grow more grass (Abdurrahman et al., 2013). In areas where labor is lacking or the work speed of farmers/farm laborers is low, row legowo planting is more difficult for farmers to adopt. In areas like this, it is necessary to introduce planting machines, both direct seed planting and transplanting (seedlings). In this case, it is necessary to consider the satisfaction of farmers who adopt the jajar legowo planting method, so that they will then enjoy ease of operation and plant care, such as fertilizing, weeding, and spraying pests, diseases and weeds which can be done more quickly and effectively.

In an effort to accelerate the dissemination of technological innovations such as the Jajar Legowo planting system, one way is through technology degrees and field meetings. Technology degrees and field meetings play a very important role in transferring technology from research results to farmers as technology users. Without dissemination, no matter how good the technology produced, if it is not known and implemented by farmers or users, the technology will not provide benefits (Herawati et al., 2021). Faqih et al. (2015) found that the effectiveness of agricultural extension methods is closely related to the application of lowland rice cultivation technology using the Jajar Legowo planting system. Therefore, it is recommended that agricultural extension officers increase regular meetings with farmers and hold demonstration plot activities, because this method is very effective for farmers to be able to apply the Legowo system of lowland rice cultivation technology. Agricultural extension techniques are closely related to lowland rice cultivation technology using the Jajar Legowo planting system. Therefore, it is recommended that agricultural extension officers use extension techniques that farmers really understand and need, such as communication techniques. With good communication techniques between farmers and agricultural extension workers, good cooperation will be established, and in the end farmers can apply the Jajar Legowo system rice cultivation technology well.

The research results of Kusmiati and Hartono (2014) show that the level of farmers' motivation and knowledge in implementing jajar legowo technology is relatively high. The internal characteristics of education level and all aspects of knowledge are significantly related to motivation. Farmers' experience is significantly related to their knowledge.

In line with the research results of Sitinjak and Idwar (2013), education has the highest relationship to the application of integrated plant management technology (PTT) (r=0.791) compared to age and experience (r= 0.646 and 0.644, respectively). Farmer experience shows the highest relationship value with knowledge, proving that a person's experience will influence the level of knowledge and skills.

Development Strategy

The rice development strategy through the Jajar Legowo planting system can be seen based on the identification of strengths, weaknesses, opportunities, and threats from the SWOT analysis as presented in Table 1. The strategy that may be developed in farmer groups is to Jajar Legowo planting system technology can increase rice production by motivating farmer groups through counseling and a direct approach by creating a demonstration plot so that farmers understand better and can immediately adopt innovative Jajar Legowo planting system technology in order to increase rice production. With an integrated rice farming management approach, starting from cultivation management (land preparation, seeding, planting, fertilizing, water management, weed control) to pest and disease management, it is hoped that it will be able to increase the productivity and efficiency of rice farming which will then have an impact on increasing income. and farmer welfare. Efforts are made through a participatory approach, namely from farmers, by farmers and for farmers. To make it easier for farmers and agribusiness actors to understand, know and imitate, a form or model of introduction and socialization is implemented in the form of field schools as a real model carried out by farmers, with farmers and for farmers.

Apart from that, increasing human resource capacity, perception and institutions with education and training. Development strategies are obtained based on the principle of maximizing strengths to make the most of opportunities or overcoming threats and minimizing weaknesses to take advantage of opportunities or threats. To support the implementation of the Jajar Legowo planting system technology, it is necessary to activate local institutions, especially in providing production facilities, so that farmers/farmer groups do not have difficulty in implementing the technology in implementing it.

Utilizing field officers as motivators to arouse farmers' desire to plant rice using the Jajar Legowo planting system and motivating farmer groups to plant rice using the Jajar Legowo planting system using an agribusiness approach and using planting equipment/transplanters through a partnership pattern. By implementing this technology, high rice production will be obtained and this will be balanced with rice selling prices that are profitable for farmers. Thus, the opportunity to increase rice productivity will increase by increasing the rice planting pattern of cropping index (IC) 200 and IC 300 in irrigated rice fields, thereby providing a positive impact on the realization of food security.

The strategy to support the development of the Jajar Legowo planting system in irrigated rice fields needs to be supported by adequate socio-economic institutions, the application of rice cultivation technology components in addition to the planting system that supports increased productivity through integrated crop management (ICM), institutional development, and coordination between agencies.

Table 1. Rice development strategy for the jajar legowo planting system in rice fields

External Factors:	**Internal Factors:**	
	Strength	**Weaknesses**
	Availability of rice technology using the Jajar Legowo planting system	Low application of Jajar Legowo system planting technology
	Availability of irrigation networks and availability of irrigation water	Additional planting costs with the Jajar Legowo planting system
	The availability of fertile land is sufficient	
(Opportunities)	**Strengths Opportunities: (SO)**	**Weaknesses Opportunities: (WO)**
Rice production is quite high in irrigated rice fields	Carrying out action programs with farmer groups implementing the Jajar Legowo planting	Developing farmers/farmer groups through extension with jajar legowo planting system technology can increase

	system technology with this technology can increase rice production and farmer income	farmers' production and income
Rice production increased by 20% with the Jajar Legowo system	Increase human resource capacity, perception and institutions with education and training	Motivate farmer groups to plant rice using the Jajar Legowo planting system using an agribusiness approach and the use of planting equipment/transplanters through a partnership pattern
(*Threats*)	**Strengths *Threats*: (ST)**	***Weaknesses Threats*:(WT)**
- Pest/disease attacks	Implementation of an integrated pest control system	Train farmers/farmer groups on integrated pest management (IPM)
	Increasing human resources (HR) in implementing the Integrated Pest Management system	Able to be a pest observer on his own land

Factors that have significant influence on adoption of *jajar legowo* system are education and land area, but age has no significant influence. The more experienced or the older, the higher the adoption rate of *jajar legowo* system. Increasing education level means increasing the adoption of *jajar legowo* system. Increasing land area means increasing the adoption of *jajar legowo* system (Payong et al., 2018).
Adopting jarwo super technology components by farmers shows a noticeable increase before and after the demo farm. The demo farm of jarwo super improves farming efficiency and farmer income (Sudaryono, 2017).

The results of Ilham et al., (2021), that the formulation of the strategy of SWOT analysis is a Strategy S-O((Strength-Opportunities), amongothers, the Development and improve the human resource capabilities of farmers in agricultural technology innovation, strategy W-O (Weaknesses-Opportunities), among others, improve the ability mastery of appropriate technology for farmers, the strategy S-T(Strength-Threats), among others, the optimization of the agricultural land and the strategy of W-T(Weaknesses-Threats), among others, use varieties that are resistant to pest and disease and able to survive extreme conditions.

CONCLUSION

1. The jajar legowo planting system provides higher rice productivity and can increase rice productivity by 12.26- 33.07% compared to the tegel planting system. Economically, the Jajar Legowo planting system is profitable and worthy of being developed on a wider scale.

2. The strategy for rice development using the jajar legowo planting system is based on an analysis of strengths, weaknesses, opportunities, and threats. The jajar legowo technology can increase rice production through a farmer group approach involving extension services and demonstration plots. An integrated, dynamic, and participatory approach to rice farming management. Besides that, efforts to enhance human resource capacity, institutional capabilities, education, and training**.**

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