



Boosting Inpago 13 Rice Yield through Mulch Innovation: A Pathway to Enhancing Yield Performance of Inpago 13

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Abstract— The increasing global population continues to elevate food demand and intensify the strain on essential natural resources such as arable land and water. Optimizing agricultural practices to enhance productivity is crucial to achieving sustainable food security. This study explores the importance of different organic and synthetic types of mulch on the growth and yield of upland rice (Inpago 13) cultivated in dryland areas. The experimental design utilized a randomized block design featuring six mulch treatments: absence of mulch, straw mulch, geowoven mulch, black-silver plastic mulch, silver-silver plastic mulch, and white plastic mulch. The findings indicated that mulching significantly enhanced agronomic traits such as tiller number, leaf area, dry biomass, milled dry grain, and 1000 dry grain ($P < 0.05$). The black-silver plastic mulch (M3) demonstrated the most substantial positive impact, achieving the highest grain yield of $8.76 \text{ ton}\cdot\text{ha}^{-1}$ and the largest leaf area ($1,479.50 \text{ cm}^2$). Compared to non-mulched treatments, plastic mulches enhanced photosynthetic performance leading to better biomass accumulation and yield efficiency. The findings underscore that mulching—especially with reflective plastic films improves physiological processes and grain yield on upland rice (inpago 13). This study highlights the potential of strategic mulch application to maximize upland rice productivity under water-limited conditions and contributes to resilient agricultural practices for future food systems.



Keywords— Mulch, Inpago 13, upland rice, photosynthesis, yield performance.

I. INTRODUCTION

The increasing population is a crucial challenge in efforts to overcome the problems of hunger and malnutrition and support sustainable development. Since 1950, the global population has experienced significant growth, reaching 8 billion in 2022. Based on projections, the population of this world it will be increased until reaching 8.5 billion in 2030 (up 10%) in 2050 it will be reach 9.7 billion (up 26%), and is even expected to reach 10.9 billion in 2100 (up 42%). There is also speculation that the global population could exceed 17 billion by 2100 (UNDESA, 2022).

The role of rice in global food is vital because it is widely used as the primary food source by most of the global population (Bandumula, 2018; Mohidem et al., 2022). Even though it only contributes 20% to the global food

energy supply, its role cannot be replaced (Gadal et al., 2019). Asia, rice provides more than 70% of caloric needs in many countries (Bin et al., 2023). Moreover, for underprivileged or malnourished people in Asia and Africa, rice is a staple food that cannot be replaced because it is easy to reach. Due to its vital role in global food needs, rice is very essential for meeting food needs and significantly impacts economic growth, job creation and social stability (FAO, 2021).

Global rice production has tripled from 1961 to 2019, increasing from 215 million tonnes to 755 million tonnes. Almost all rice in the world is produced in the Asian region (Beerelli et al., 2023; Sharma et al., 2023), with more than 80% of global production produced by seven countries in Asia such as China, India, Bangladesh, Vietnam, Myanmar, and Thailand (Bandumula, 2018;

Fahad et al., 2019). This is influenced by the increase in rice consumption per individual in several Asian countries (Cosslett et al., 2018). Factors triggering increased demand in Asia include rapid population growth, increasing urbanization, increasing incomes, changes in diet to staple foods, and several other factors (Bashir & Yuliana, 2018; Chauhan et al., 2017).

There are two types of rice plants: 1) rice, which grows on dry land, and 2) wetland rice, which requires standing water. Field rice is an example of a rice crop that can be planted on flat and sloping dry land without galvanizing. Every yield and productivity of rice fields depend on rain water, which affects soil moisture. One type of rice is upland rice, which can be cultivated permanently on dry land. This plant has advantages such as resistance to drought and disease and requires little water for growth (Wijayanto et al., 2021).

The increase in human population has triggered increasingly fierce competition for access to natural resources, including land and water while increasing the need for food supplies (Iqbal et al., 2020). Areas that are generally dry or semi-arid, covering most land areas throughout the world, its play a chance and challenges of the global food security crisis. One practical step to strengthen food security is to increase the productivity of rice plants per area of land planted (Firdaus et al., 2020). Because dry areas have limited rainfall, affecting agricultural production, efforts are needed to increase productivity and crop yields by improving how agricultural land is managed (Vial et al., 2015).

Using a cover land such as mulch in areas with dry and semi-arid climates is considered an environmentally friendly agricultural strategy because it can maintain soil moisture, reducing dependence on irrigation (El-beltagi et al., 2022). Compared to conventional soil management methods, mulch significantly reduces water loss through evaporation, surface runoff, and soil erosion and increases retention of water in the soil (Humphreys & Eberbach, 2021). Both organic and synthetic mulches is another way to increase crop yields. This research aims to evaluate the impact of mulch on the productivity of upland rice of the Inpago 13 variety. This research has never been carried out, but similar research on the effect of applying straw mulch and nitrogen movement on rice growth, dry plant accumulation and quality has been carried out by Yan et al., (2018), and the influence of different mulch colours was carried out by Zhang et al. (2023). The information presented in this research is necessary to support food security due to the increasing demand for rice in Asian countries, especially Indonesia.

II. MATERIAL AND METHOD

The research was executed from august 2023 until December 2023 at the experimental field in Jatimulyo, under the Faculty of Agriculture, Brawijaya University, Malang. Equipment included an altimeter, cultivator, leaf area meter, knapsack sprayer, analytical balance, Memmert oven, and soil moisture meter. Inpago 13 rice seeds, NPK compound fertilizer (15:15:15), and urea (46% nitrogen) were used.

The experimental method used was group randomized block design with six types of treatment, namely: No mulch, Straw mulch, Geowoven mulch, Black Silver Plastic Mulch (MPHP), Silver Silver Plastic Mulch (MPPP), and White Plastic Mulch (MPP). In this treatment it was repeated until 4 times, 24 trial, each consisting of 192 rice plants.

The variables observed are plant height, dry weight plant, milled dry grain, number of tiller, leaf area.

III. RESULTS AND DISCUSSION

The data research give an information that use of different types of mulch had a significant effect ($P < 0.05$) on number of tiller (Table 1). The data research explain that any types of mulch had a significant effect ($P < 0.05$) on tiller number of upland rice plants (Table 1).

The data research explain that any types of mulch had a significant effect ($P < 0.05$) on the leaf size of upland rice plants (Table 1). Highest leaf size was found when using black silver plastic, with leaf area size 1,479.50 cm² which was the same as the straw mulch treatment, namely 1,339.69 cm².

Meanwhile, the low leaf size has been found when using the silver silver plastic mulch which was the same as the geowoven mulch, namely 775.69 cm² and 827.06 cm².

Research conducted by Hou et al. (2015) and Mo et al. (2017) found that plants expansion cell with mulch experienced increased photosynthesis rates. Additionally, the research also explain that the ever some plants exhibited preferable root growth and a more remarkable potentiality to maintain an absorb nutrients from the soil, as observed in research by Jia et al. (2018); Wang and Xing (2016), in past research it says that using mulch can increase a plant grown. Recent research in semi-arid areas also found that the use of plastic film mulch affects plant assimilation processes, as mentioned by Wang et al. (2015). The negative effect of drought on every plant photosynthesis has been observed by Zargar et al. (2017) and Chen et al. (2021).



Fig 1. Different effect of mulch on upland rice (inpago 13); M0: no mulch, M1: straw mulch, M2: geowoven mulch, M3: black silver plastic mulch, M4: silver mulch, M5: white plastic mulch.

Physiologically, abscisic acid (ABA) is known as an early signal from lack of water stress that regulates photosynthesis on the leaf processes. When plant roots detect a decrease in soil water potential, ABA production

increases to regulate stomatal conductance, which in turn reduces water loss before the plant experiences a significant water deficit, as has been observed by Yang et al. (2017).

Table 1. Effect of mulch on upland rice Inpago 13

Treatment	Leaf Size (cm ²)	Number of Tiller	Dry Weight per Plant (g)	Milled Dry Grain (MDG) per Hectare (ton Ha ⁻¹)	1000 Grain Weight (g)
No Mulch	1.113,31 bc	33,64 a	119,14 ab	5,43 a	23,49 ab
Straw Mulch	1.339,69 cd	40,56 bc	130,32 bc	6,70 b	25,14 b
Geowoven Mulch	827,06 ab	31,44 a	104,79 a	4,75 a	22,48 a
Black Silver Plastic Mulch	1.479,50 d	44,38 d	154,01 d	8,76 d	28,20 c
Silver Mulch	775,69 a	37,58 b	124,88 bc	6,81 b	24,19 ab
White Plastic Mulch	1.152,58 c	41,63 cd	139,68 cd	7,91 c	25,50 b
LSD (5%)	300,33	3,50	15,83	0,75	2,60

Notes: Numbers accompanied by the same letter are not significantly different based on the 5% LSD test; LSD = Least Significant Difference; g = gram; Ha= hectare.

Therefore, under moderate water deficit conditions, the response of photosynthetic rate to soil drought may be less sensitive than the response of leaf size, which impacts the efficiency of water use by plants in dry land and arid regions. Thus, under moderate water deficit conditions, the photosynthetic rate response to soil drought may be less sensitive than the stomatal conductance response, which has implications for water use efficiency (Zhang et al., 2019).

Plastic films used as mulch help increase water flow to the surface through capillarity and divert water vapour, which is then retained on the soil surface (Zhang et al., 2018).

Thus, mulching helps to overcome soil moisture deficiencies that may arise due to photosynthesis by storing soil water to support the process. In addition, the use of mulch can also improve water use efficiency by redirecting water that may evaporate back to the plants by Jia et al. (2018) and Luo et al. (2016). This can stimulate plant root activity and successively increase photosynthesis. Another benefit from using mulch, the use of plastic soil cover can also accelerate plant growth that can be impact on leaf size by Wang et al. (2015) and Zhang et al. (2017).

The data observations on the upland rice plants also showed that the use of different mulches had a significant impact ($P < 0.05$) on the tiller number and dry weight plant (Table 1). The black silver plastic mulch had the same tiller number as 44.38 as the black and white plastic mulch, which was 41.63. The treatment absence of mulch and geowoven mulch produced the lowest tiller number among all mulch treatments, which were 33.64 and 37.58. The collected data showed information that using different mulches had a significant effect ($P < 0.05$) on dry weight per plant. The black silver plastic mulch treatment

154.05gr had the highest dry wight per plant, while the lowest was in the silver mulch 124,88gr and gewowoven mulch 104,79gr treatments. The data collected of this study are same with research conducted by Franquera and Mabesa (2015), which found that the apply of plastic mulch on land cultivation significantly increases the weight of lettuce leaves compared to other colours of plastic mulch. Zuliati et al. (2020) also give information that using of mulch on onion plants can increase the Dry Weight per Plant.

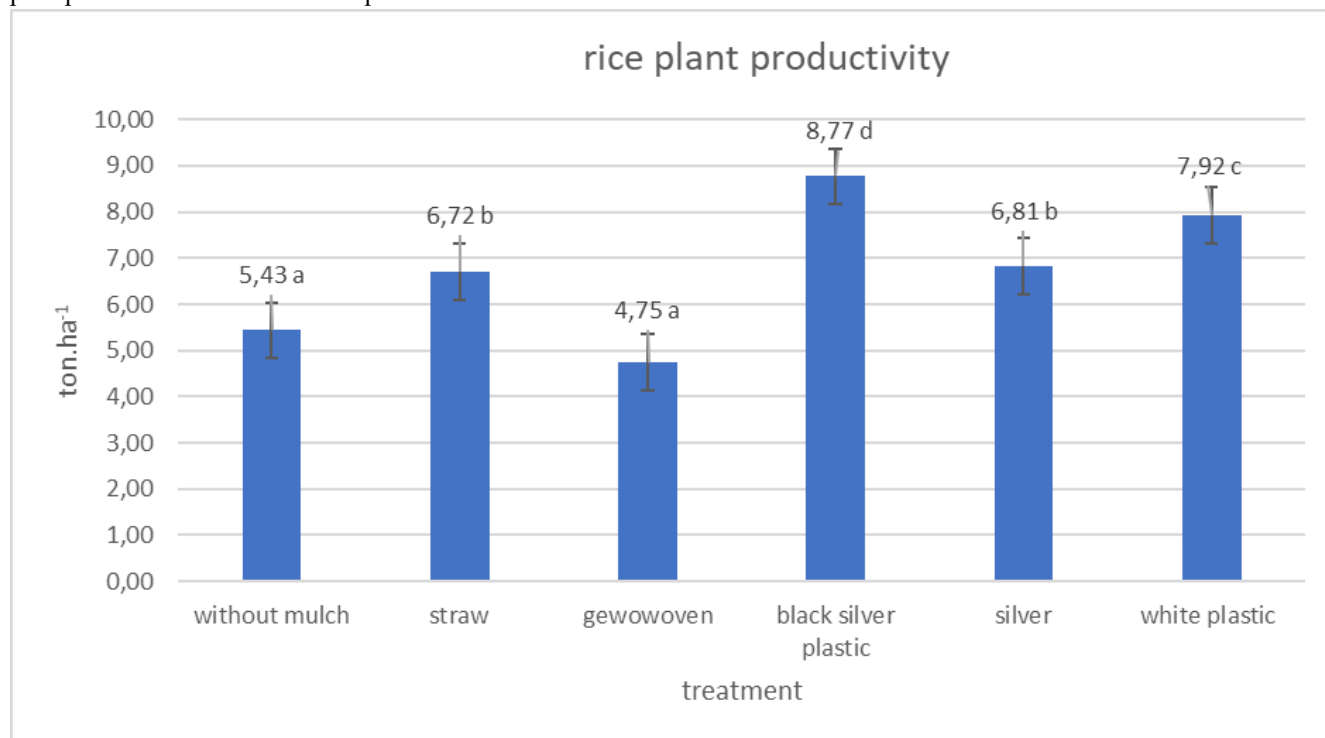


Fig 2. The effect of mulch types on the productivity of upland rice (inpago 13)

The data observed also showed that the use of different mulches had a significant influenced ($P < 0.05$) on the dry milled rice per hectare and the weight of 1000 grains. The highest dry milled rice per hectare was seen in black silver plastic 8,76 ton.ha⁻¹, while the lowest was in geowoven 4,75 ton.ha⁻¹ and absence of mulch 5,43 ton.ha⁻¹. The highest 1000-grain weight was seen in M3 28.20 g, while the lowest was in M2 22.48 g. The use of mulch affects water absorption by the roots, which can affect plant health. Using mulches, such as rice straw, can help reduce heat flow to the soil and retain moisture. Using organic mulches, the soil can be kept at an optimal temperature during various seasons, and water loss due to evaporation can be minimized (Peng et al., 2015; Fabrizzi et al., 2005). Organic mulches can help regulate sun exposure and maintain a balanced soil climate to support healthy plant growth (Kusbiantoro et al., 2023).

Based from research conducted by Kusbiantoro et al. (2023), organic materials such can effectively keep soil temperature in areas with hot climates. This phenomenon occurs due to heat transfer through conduction between the mulch and clay layers at the surface, affecting the soil's climate capacity. The cooling effect from using organic mulches, such as rice straw, can be observed by forming a dry layer on the soil surface, which causes water to be condensed from the air periodically. This process allows water vapour to be absorbed into the soil through diffusion, which effectively helps maintain soil moisture. In addition, organic mulch also acts as a barrier to the growth of plant roots that tend to grow towards the surface, thus slow down rate of water evaporation from the soil.

IV. CONCLUSION

Different mulches were significantly affected ($P < 0.05$) by, Leaf Siza, Number of Tiller, Dry weight per Plant, milled dry grain per hectare, and 1000 grain weight. The results showed that M3 (silver black plastic mulch) had the highest milled dry grain every hectare 8,76 ton.ha⁻¹. The observation in the plant growth directly proportional to the production of upland rice var Inpago 13.

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