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Effects of different management practices on the growth and yield of corn

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Abstract

In Indonesia, corn is an important commodity that serves as the second source of carbohydrates after rice, whose productivity is influenced by management practices applied during cultivation. This research aimed to determine the effects of different management practices on the growth and yield of corn. This research was arranged in a single-factor Randomized Complete Block Design, with different agriculture management practices as treatments, consisting of TI1 = Best Practices (Drip Irrigation + Rice Husk + Mycorrhiza), TI2 = Farmers' Practices (Furrow Irrigation) + Mycorrhiza, and TI3 = Farmers' practices (Furrow Irrigation). The data observed were analyzed using Analysis of Variance and followed by the Post Hoc Tukey's HSD at α= 5%. The results showed that the TI1 produced significantly higher plant height, stem diameter, leaf dry weight, weight of cob with cornhusk and kernel dry weight, and effectively suppressed weed growth compared to TI2 and TI3. TI1 produced a significantly higher number of leaves, root dry weight, and total dry weight compared to TI3, but not significantly different compared to TI2. TI1 produced not significantly different stem dry weight and harvest index compared to TI2 and TI3. The kernel dry weight per plant observed in TI1 was 157.63 g, which was 14.22% and 22.91% higher than in TI2 and TI3, respectively. Based on the coefficient correlation and path analysis, the number of leaves, plant height, and total dry weight should be considered as important plant growth variables to produce high kernel dry weight.

INTRODUCTION

Corn or maize (*Zea mays* L.) is one of the most important cereal crops worldwide that can be used to produce feed, fuel, and as a raw material for diverse products at the industrial level (Ranilla, 2020). The need for corn will continue to increase in line with the increase in demand from consumers. Corn productivity and production in Indonesia reached 5.6 tons.ha^{-1} and 25.18 million MT of dry kernels by 2022 (Suwandi, 2022). The productivity of corn in Indonesia is still below its potential productivity, which can reach 12.83 tons.ha^{-1} (Aristya and Samijan, 2022).

Corn productivity is influenced by the management practices applied during cultivation. Crop management including land preparation, fertilization, irrigation, weed control, and pest and disease management is carried out as a practical management that aims to improve the growth, development, and yield of crops. In contrast to other crops, corn is very sensitive to water availability during the growth stages. Corn production requires significant amounts of water (Henry and Krutz, 2016) to improve yield (Spencer et al., 2019), while water scarcity is becoming more serious globally as a result of climate change and population increase (Wang et al., 2021). One of the efforts to increase corn productivity is by irrigation water management (Asres, 2023).

Corn irrigation can be done using various techniques to ensure sufficient water supply for plant growth and

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production. The selection of appropriate irrigation techniques must consider various factors such as soil conditions, topography, crop types, climate, water availability and quality, available infrastructure, and investment to obtain optimal results (Rai et al., 2017). Drip irrigation technology is a new type of surface irrigation technology used to adapt to the development of water-saving agriculture and used in arid and semi-arid regions (Wang et al., 2021). Drip irrigation is now commonly used for corn cultivation to increase crop yield and Water Use Efficiency/WUE (Ma et al., 2021).

Drip irrigation is a proven technology to reduce water conveying and application losses (Sujatha et al., 2023). In drip irrigation, water is supplied to the crop drop by drop at a very low rate from a small hose with outlets called emitters for drippers. Drip irrigation is 40% more efficient because it uses 40% less water than the conventional method of irrigation (Ranjan and Sow, 2021). Drip irrigation can effectively improve the growth, yield, and WUE of corn (Liu et al., 2022). Drip irrigation is better performed to improve crop water productivity than conventional irrigation systems (Asres, 2023).

Combining drip irrigation with organic mulch is a highly effective approach to sustainable agriculture. When combined with mulching, this technique improves fertilizer utilization and reduces water consumption (Yang et al., 2023). Using organic mulch reduces water stress in the root zone area and increases organic matter, crop yield, and water productivity while providing energy savings of up to 50% (Alhashimi et al., 2023). Combining drip irrigation with rice husk as an organic mulch can provide benefits such as reducing evaporation losses (Sudprasert and Sankaewthong, 2018), increasing nutrient efficiency (Thiyageshwari et al., 2018), reducing or preventing runoff and soil loss in loamy soil (Ahmadi, Ghasemi and Sepaskhah, 2020), and inhibiting weed growth (Nurjanah et al., 2021).

The intensive practices of modern agriculture have an adverse environmental impact on soils, increasing greenhouse gas emissions, nutrient leaching due to intensive fertilizer application, soil erosion, and decreasing biodiversity (Karimi et al., 2020). Therefore, seeking environmentally friendly management practices is very important to reduce these adverse impacts. This research has suggested beneficial microorganisms. Beneficial microorganisms as bio-stimulants and biocontrol have an important role in plant growth and health (Compant et al., 2019), strengthen beneficial microbial networks and determine the biological quality of soils (Torres, Yu and Kaan Kurtural, 2021), and improve plant nutrition and crop productivity under environmental stress (Jalal et al., 2023). Arbuscular mycorrhizae fungi are vital symbionts due to their multiple benefits to mitigate these adverse impacts (Pop-Moldovan et al., 2021).

Arbuscular mycorrhizae fungi can form hyphal structures that expand the absorption area of the roots (Miceli et al., 2023). This helps corn plants to absorp essential nutrients such as Phosphorus and other nutrients that tend to be difficult to reach in the soil (Buzo et al., 2022). Inoculation of mycorrhiza in corn plants can increase corn productivity (Agbodjato et al., 2022) and sustainability production (Pedroso et al., 2022). The symbiosis between mycorrhiza and corn roots improves the root vigor of corn and promotes nutrient accumulation at the root system (Ma et al., 2022).

The application of drip irrigation, rice husk as organic mulch, and mycorrhiza is expected to be a combination of best management practices. This research aimed to determine the effects of different management practices on the growth and yield of corn.

MATERIALS AND METHODS

Research design

The research was conducted from March to July 2023 on agricultural land of Agricultural Extension Center Simou, Labuan Toposo Village, Labuan District, Donggala Regency, Central Sulawesi Province, Indonesia, located at 0°38'06.1"S 119°51'00.4"E and at an altitude 0f ±128 m above sea level (asl). The materials used were corn (*Zea mays* L.) NK6501 Super variety hybrid corn seeds, 300 $kg.ha^{-1}$ compound fertilizer (16% N, 16% P_2O_5, 16% K_2O), 200 $kg.ha^{-1}$ Nitrogen fertilizer (46% N), 75 $kg.ha^{-1}$ KH_2PO_4 fertilizer (52% P_2O_5, 34% K_2O), 1 $ml.l^{-1}$ plant growth stimulant/ hormone (gibberellic acid and cytokinin), 20 $kg.ha^{-1}$ PGPF (Mycorrhiza contains 33 spores per gram, 300 active propagules per gram, 5 endomycorrhizas species), and 4 $kg.m^{-2}$ rice husk.

The research was arranged in a single-factor Randomized Complete Block Design (RCBD), with three treatments and four replications in the same area as a block, in which each replication consisted of 4 sample plants that were harvested at 110 days after planting (DAP). The treatment was the different agriculture management practices, including 1) TI1 = Best Practices (Drip Irrigation+Rice Husk+Mycorrhiza), 2) TI2 = Farmers' Practices (Furrow Irrigation) + Mycorrhiza, and 3) TI3 = Farmers' practices (Furrow Irrigation).

The drip irrigation used was surface drip irrigation with a hydrosol hose type, which is a method of watering that delivers water slowly and directly to the plant root system through a hydrosol hose placed around the plant (Ranjan and Sow, 2021). In furrow irrigation, water was conveyed through small channels with a gentle slope towards the downstream end every 2 days or accorded to soil moisture conditions (Seeda et al., 2020). The design of irrigation systems in the research area can be seen in Figure 1.

Research procedure

The research site was a paddy field. The soil was thoroughly plowed, with the difference between plowed 1 and plowed 2 was 1 week. Experimental plots were made with a size of 9 m x 8 m. A pre-emergent herbicide was sprayed 3 days before planting at a dose of 0.875 ml.l^{-1}. In each experimental plot, planting holes were made with a spacing of 70 cm x 20 cm, and then 1 corn seed was planted in each hole with a depth of about 3–5 cm. After the plants grew, rice husk as organic mulch at a dose of 4 kg.m^{-2} was applied at 1 WAP (Weeks After Planting) above the soil surface to the TI 1 experimental plot. Irrigation was carried out ideally every other day according to each irrigation system treatment and adjusted to the environment and weather conditions. Pest management such as armyworms was carried out with insecticide at a dose of 1.25 ml.l^{-1}.

Compound fertilizer (16% N, 16% P_2O_5, 16% K_2O) at a dose of 300 kg.ha^{-1} was applied 3 times, i.e. 105 kg.ha^{-1} at 2 WAP, 135 kg.ha^{-1} at 5 WAP, and 60 kg.ha^{-1} at 7 WAP (Pusparini et al., 2018). Nitrogen fertilization at a dose of 200 kg.ha^{-1} was applied 3 times, i.e. 50 kg.ha^{-1} at 2 WAP, 70 kg.ha^{-1} at 5 WAP, and 80 kg.ha^{-1} at 7 WAP (Tabrani and Saiful, 2023). Fertilization of KH_2PO_4 was applied 3 times, i.e. 18.75 kg.ha^{-1} at 2 WAP, 26.25 kg.ha^{-1} at 5 WAP, and 30 kg.ha^{-1} at 7 WAP. Plant growth stimulant was applied 2 times, i.e. 0.5 ml.l^{-1} at 2 WAP and 0.5 ml.l^{-1} at 7 WAP. Mycorrhiza at a dose of 20 kg.ha^{-1} (4 g.plant^{-1}) was applied once at 2 WAP with a spot placement technique in the treatment of T1 and T2. Corn was harvested at 110 DAP when the corn cobs turned brown and hardened, and the corn silks dried out, turned brown and shriveled.

The research variables observed were plant growth

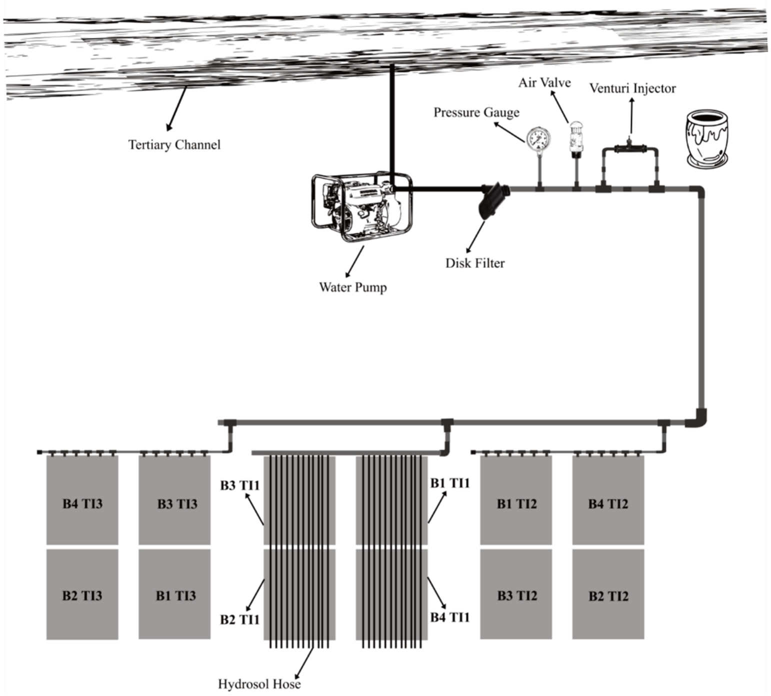

Figure 1. Design of irrigation systems in the research area

Remark: TI1 = Best Practices (Drip Irrigation + Rice Husk + Mycorrhiza), TI2 = Farmers' Practices (Furrow Irrigation) + Mycorrhiza, TI3 = Farmers' practices (Furrow Irrigation). B1 = Block 1, B2 = Block 2, B3 = Block 3, B4 = Block 4.

components and plant yields. Plant height (cm) was measured using a ruler every other week (2–14 WAP). Number of leaves and stem diameter (mm) were measured at 2 WAP (V3-V5 phase), 6 WAP (V11-Vn phase), and 14 WAP (R6 Phase). The stem diameter was measured using a caliper. The weight of the cob with cornhusk ($g.plant^{-1}$) was measured using a digital scale at 110 DAP. Stem dry weight ($g.plant^{-1}$), leaf dry weight ($g.plant^{-1}$), root dry weight ($g.plant^{-1}$), and total dry weight ($g.plant^{-1}$) were measured using digital scale at 112 DAP (16 WAP) after being oven dried at 80°C until they reached a constant weight. Kernel dry weight ($g.plant^{-1}$) was measured by drying the kernels under the sun for 2 days after being separated from the cobs, then the kernel dry weight was measured using a digital scale at 112 DAP (16 WAP). Harvest index was the result of the proportion of kernel dry weight (g) to the total plant dry weight (g).

Data analysis

The data were analyzed using Analysis of Variance (ANOVA), followed by the Post Hoc Tukey's HSD (Honestly Significant Difference) Test at the α level of 5%. The correlation analysis was used to measure the strength of the linear relationship between two variables. To facilitate interpretation, a Pearson correlation coefficient was commonly used. This coefficient is a dimensionless measure of the covariance, which is scaled such that it ranges from -1 to +1; a value of -1 means a total negative linear correlation, 0 is no correlation, and +1 means a total positive correlation (Schober et al., 2018). Path coefficient analysis is a technique by which we can divide the correlation coefficients into direct and indirect effects. The variables under the study were classified as dependent variable and independent variables (Wamanrao et al., 2020). In path analysis, kernel dry weight was used as the dependent variable, the total dry was is used as the intervening variable (mediator), and the other variables were used as the independent variable. The statistical analysis was performed using the SAS 9.4 program and R Studio program.

RESULTS AND DISCUSSION

Plant height of corn

Plant height is a fundamental morphological phenotype that directly indicates plant growth and is highly predictive of biomass and grain yield (Wang et al., 2018). Plant height can be measured directly from the shortest distance between the upper boundary of the main photosynthetic tissues (excluding inflorescences) on a plant and the ground level (Pérez-Harguindeguy et al., 2013). The sigmoid growth curve of corn plant height from 2–14 WAP (weeks after planting) is presented in Figure 2. The sigmoid curve is a typical nonlinear model category with models typically used to describe plant height (Hsieh et al., 2021). This curve mainly shows four phases of growth, consisting of initial slow growth (lag phase), the rapid period of growth (log phase/grand period of growth/exponential phase) where maximum growth is seen in a short period, the diminishing phase where growth will be slow, and stationary/steady phase/senescence phase where growth finally stops (Suryawanshi, 2022). In the initial phase (2–4 WAP), growth was relatively slow but accelerated after that

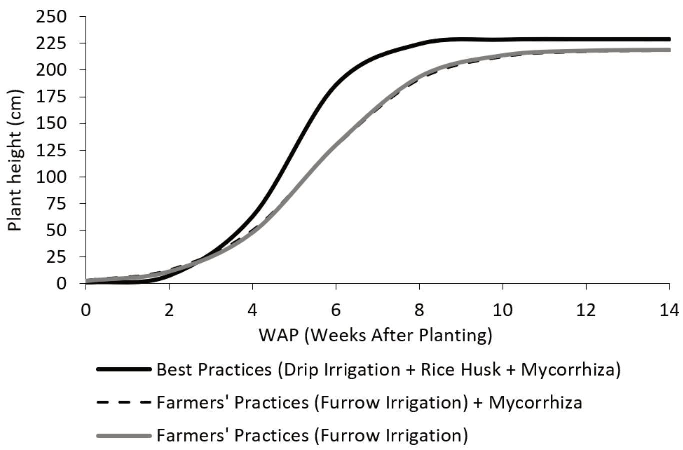

Figure 2. The sigmoid growth curve of corn plant height as affected by different management practices

(6–8 WAP) and decreased in the stationary phase (10–14 WAP) (Figure 2).

In Figure 2, the best practices treatment showed a higher significant effect on the plant height compared to the other treatments until the end of the corn growth phase. Best practices treatment (drip irrigation + rice husk + mycorrhiza) was a good management practice that can increase the growth of corn plant height. According to the results of research by Usoh et al. (2017), corn plants irrigated by the drip method had a higher plant height compared to corn plants irrigated by the furrow method. Drip irrigation systems promote root system expansion, leading to increased plant growth and vigor. Drip irrigation provides small amounts of water to plants at frequent intervals, reducing evaporation losses, and preventing foliage wetting. It is also delivered at or below ground level (Bhasker et al., 2018). Drip irrigation increased the height of corn plants due to the constant availability of water, allowing for faster cell growth compared to without drip irrigation. (Muslimah et al., 2022).

Application of rice husk and mycorrhiza in drip irrigation treatment gave a higher acceleration effect on corn plant height, especially at the 6 WAP (tasseling stage of corn). Rice husk mulch is known to improve water storage, protect the soil surface against raindrops, decrease soil temperature, and slowly release nutrients over time (Salahudeen and Sadeeq, 2018). Mulching material such as rice husk has increased the soil's organic matter after one season and improved the soil's physical and biological properties, thus significantly increasing plant height compared to no mulch treatment (Sharma et al., 2023). According to Huey et al. (2020), there was a higher growth rate in plants inoculated with mycorrhiza than in control plants due to an increase in photosynthetic activity. Application of mycorrhiza can improve plant nutrition uptake, water uptake, growth (plant height), and production (Sheikh-Assadi et al., 2023).

Corn plant height in the furrow irrigation with mycorrhiza treatment showed no significant difference from corn plant height in the furrow irrigation. Application of mycorrhiza in furrow irrigation did not have a significant effect due to the possibility that mycorrhiza was leached with irrigation water so its effect was not expressed in the plant height of corn. According to the results of research by Deng et al. (2022), the application of mycorrhiza in furrow irrigation did not enhance soil enzyme activities and nutrient content (total Nitrogen, total Potassium, total Kalium, and soil organic matter). Lack of water resources, high water consumption, and inadequate flood irrigation have significantly reduced yield and quality. Furrow irrigation poses some important environmental problems; nutrient leaching, higher erosion (Seeda et al., 2020), and runoff in the experimental sites represented up to 70% of the applied water (ranging from 20 to 70%) (Araujo et al., 2019).

Number of leaves

Leaves are one of the main plant parts required for biomass production of the plant through photosynthesis (Nasution et al., 2021). The number of leaves is one of the main visual (phenotype) characteristics that describe the growth and development of plants (Farjon et al., 2021). The best practices treatment showed a higher significant effect on the number of leaves compared to the farmers' practices (furrow irrigation) at 2, 6, and 14 WAP (Figure 3). The best practices treatment was able to increase the number of leaves, but not significantly different compared to the number of leaves of corn in the farmers' practices (furrow irrigation) with Mycorrhiza at 2, 6, and 14 WAP. According to the results of research by Usoh et al. (2017), corn plants irrigated by the drip method had a higher number of leaves compared to corn plants irrigated by the furrow method. Rice husks can increase the nutrient availability and growth of corn (Saranya et al., 2018). Rice husk as an organic mulch can decrease soil temperature than un-mulched soil, reduce water loss into the atmosphere through evaporation, reduce surface runoff, and increase soil moisture content, thereby showing better results in the number of leaves (Sharma et al., 2023). According to the results of research by (Ramli, 2017) and (Sharma et al., 2023), rice husk mulch had a significant effect on the number of leaves. Providing organic mulch had a significant impact on both the growth of various components and plant growth rates. Mulching the soil surface increases its porosity, allowing for better water absorption and longer shelf life for groundwater. Mulching with rice husk improves soil moisture and promotes plant growth, including the number of leaves (Ramli, 2017). Mulching reduces evaporation and maintains proper moisture content, resulting in a higher number of leaves than un-mulching (Bharati et al., 2019).

Mycorrhizae establish a connection with roots using hyphae and can extend the plant's reach beyond

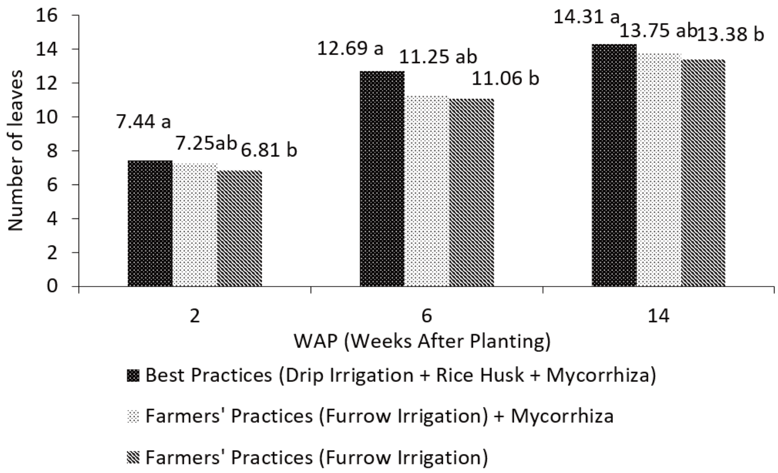

Figure 3. Number of leaves of corn as affected by different management practices
Remark: Means followed by different letters are significantly different at the 5% significance level by Tukey's test.

the root system. This expansion increases the plant's access to essential nutrients and water, thereby enhancing the growth of the number of leaves. As in the results of plant height, the number of leaves in the furrow irrigation with mycorrhiza treatment showed no significant difference from the number of leaves in the furrow irrigation. Application of mycorrhiza in furrow irrigation did not have a significant effect due to the possibility that mycorrhiza was leached with irrigation water so its effect was not expressed in the number of leaves. Furrow irrigation was considered a major source of nutrient leaching (Araujo et al., 2019). Furrow irrigation of corn is thought to contribute significantly to nitrate leaching and groundwater contamination. Clay loam soil can leach out about 40% of the available nitrate in the root development zone (Artiola, 1991). Furrow irrigation is used globally and is a significant source of nitrate leaching (Siyal et al., 2012). Nitrogen is easily leached from the root zone by percolating water due to its high solubility (Siyal and Siyal, 2013). Leaching of NO_3^- is caused by varying water distributions in furrow irrigation. The leaching of NO_3^- is significantly correlated with NO_3^- accumulation in the soil (Yang et al., 2020).

Stem diameter of corn

Stem diameter was measured to evaluate the agronomic traits. A larger stem diameter indicates more reserves and assimilates accumulation, thus better kernel filling (Irmak et al., 2022). The best practices treatment showed a higher significant effect on stem diameter compared to the farmer's practices (furrow irrigation) + mycorrhiza and the farmers' practices (furrow irrigation) at 2, 6, and 14 WAP (Figure 4). According to Usoh et al. (2017), corn irrigated by the drip method had a higher stem diameter compared to corn plants irrigated by the furrow method. Stem diameter in the best practices treatment of drip irrigation was larger than the other treatments mainly due to better soil moisture availability coupled with improved nutrient uptake, which has favored cell elongation and division, leading to higher corn growth (Sujatha et al., 2023). The larger the stem diameter of corn, the more assimilates are produced, resulting in greater plant biomass produced. The application of rice husk in the best practices treatment contributed to a decrease in soil temperature than un-mulched soil. Rice husk prevented contact between the soil and dry air, which reduced water loss into the atmosphere through evaporation, reduced surface runoff, reduced moisture depletion, increased soil moisture content, increased the soil's organic matter, improved the soil's physical and biological properties after one season, and showed better in term of stem diameter growth (Sharma et al., 2023).

In Figure 4, mycorrhiza in the best practice management treatment showed significantly higher stem diameter compared to mycorrhiza in farmer's practices at 2, 6, and 14 WAP. Previous research showed that AMF symbiosis could increase the stem diameter of corn (Rustikawati et al., 2022). These results suggested that arbuscular mycorrhiza fungi (AMF) increase N, P, and K accumulation in corn. AMF increased the accumulation of nutrients and influenced the distribution of nutrients in maize organs compared to without AMF plants (Ma et al., 2022).

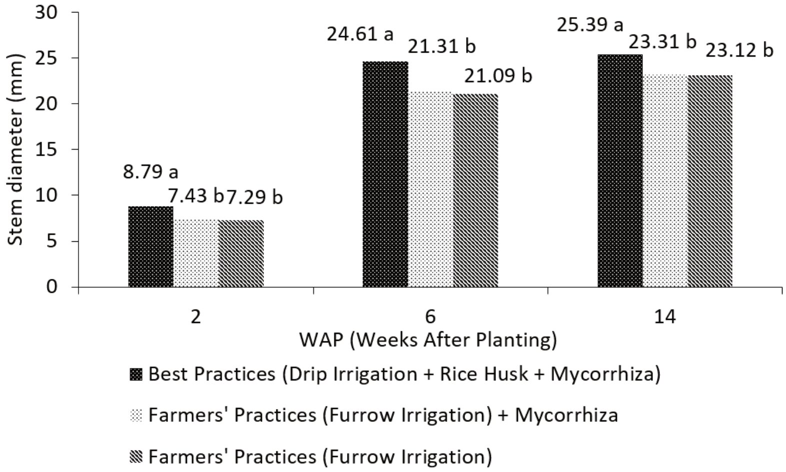

Figure 4. Stem diameter of corn as affected by different management practices
Remark: Means followed by different letters are significantly different at the 5% significance level by Tukey's test.

The mycelial network of fungi extends under the plant's roots, promoting nutrient uptake that would otherwise be unavailable (Begum et al., 2019), thereby improving corn plant growth, such as stem diameter. The difference between the treatments was that the best practices used drip irrigation and rice husk, while the farmer's practices used furrow irrigation without the addition of mulch (rice husk). Mycorrhiza treatment in furrow irrigation was not significantly different from furrow irrigation treatment without mycorrhiza on stem diameter. Same as in the results of plant height and the number of leaves, the application of mycorrhiza in furrow irrigation did not have a significant effect due to the possibility that mycorrhiza was leached with irrigation water so its effect was not expressed in the stem diameter of corn.

Stem dry weight, leaf dry weight, root dry weight, total dry weight of corn, and weed dry weight

Dry weight is the result of photosynthate assimilation that is translocated from roots to all parts of the plant. The dry weight of the plant is an important signal indicating environmental factors, and the growth condition of corn during the vegetative and generative periods was divided into stem dry weight, leaf dry weight, root dry weight, and total dry weight (Koca and Erekul, 2016). There was no significant different effect of the treatments on the stem dry weight of corn (Table 1). The best practices treatment showed a higher significant effect on leaf dry weight compared to the farmer's practices (furrow irrigation)+mycorrhiza and the farmers' practices (furrow irrigation) at 16 WAP. The significantly greater leaf dry weight was influenced by the significantly greater number of leaves in the best practices treatment at 16 WAP. Root dry weight and total dry weight were significantly affected by management practices. The best practices treatment showed a higher significant effect on root and total dry weight compared to the farmers' practices (furrow irrigation) at 16 WAP.

Drip irrigation combined with rice husk mulch and mycorrhiza application was more effective for watering plants compared to furrow irrigation in corn crops. That was represented by dry weight as a result of the plant growth process. According to Seeda et al. (2020), the problem with furrow irrigation was that water draining off the field can carry fertilizer with it. Therefore, improper fertigation strategies might lead to loss of Nitrogen fertilizer resulting in surface and groundwater pollution.

According to Nurjanah et al. (2021), rice husk mulch treatment produced a lower average weed dry weight than without mulch. Rice husk mulch on the best practices treatment effectively suppressed weed growth by 163.63–281.81%, so it did not inhibit growth and produced greater dry weight than plants without rice husk mulch treatment. Organic mulch such as decomposed rice husk and hummus was supplied to the soil, increasing water holding ability, and thereby improving irrigation water efficiency. Mulch had an impact on shoot and root biomass because it altered the soil energy balance by limiting soil water evaporation, which affected the uptake and transfer of essential nutrients (Sharma et al., 2023).

Mycorrhiza treatment increased root hair growth in the root system (extraradical mycelium of the

Table 1. Stem dry weight, leaf dry weight, root dry weight, total dry weight of corn, and weed dry weight at 16 WAP

Treatments	Stem dry weight (g plant^{-1})	Leaf dry weight (g plant^{-1})	Root dry weight (g plant^{-1})	Total dry weight (g plant^{-1})	Weed dry weight (kg.m^{-2})
Best practices (Drip irrigation + Rice husk + Mycorrhiza)	248.88 a	105.88 a	85.70 a	440.45 a	0.11 c
Farmers' practices (Furrow irrigation) + Mycorrhiza	210.83 a	95.50 b	82.63 ab	388.95 ab	0.29 b
Farmers' practices (Furrow irrigation)	182.23 a	91.75 b	80.00 b	353.98 b	0.42 a
Coefficient of variation (%)	16.71	4.56	3.06	10.02	5.32

Remark: Means followed by the different letters in the same column are significantly different at the 5% significance level by Tukey's test. WAP = Weeks After Planting.

Table 2. Weight of cob with cornhusk, kernel dry weight, and harvest index of corn at 16 WAP

Treatments	Weight of cob with cornhusk (g plant^{-1})	Kernel dry weight (g plant^{-1})	Harvest Index
Best practices (Drip irrigation + Rice husk + Mycorrhiza)	437.25 a	157.63 a	0.36 a
Farmers' practices (Furrow irrigation) + Mycorrhiza	334.88 b	138.00 b	0.36 a
Farmers' practices (Furrow irrigation)	326.63 b	128.25 b	0.36 a
Coefficient of variation (%)	3.70	3.55	9.42

Remark: Means followed by the different letters in the same column are significantly different at the 5% significance level by Tukey's test. WAP = Weeks After Planting.

fungus), which increased water uptake and nutrient uptake, especially P availabilities in the soil for plant growth (Sheikh-Assadi et al., 2023). Mycorrhizal application increased microbial colonies/microbial populations due to the increased soil organic carbon content due to the mulch, which was considered as one of the main food supplies for microorganisms (Sharma et al., 2023). Mycorrhiza application in best practice treatment increased leaf dry weight, while the plant growth parameter, such as root dry weight and total dry weight were not significantly different from the farmer's practices (furrow irrigation) + Mycorrhiza. In Table 1, farmers' practices (furrow irrigation) gave the lowest dry weight of roots, leaves, and total dry weight compared to other treatments.

Weight of cob with cornhusk, kernel dry weight, and harvest index of corn

Yield is a result of crop growth. Higher growth might have resulted in higher photosynthate, carbon assimilation, and carbohydrate reserves in the plant, which helped in the development of a higher-weight reproductive organ (Sujatha et al., 2023). Corn responded significantly differently to drip and furrow irrigation treatment judging from its yield characteristics, including the weight of cob cornhusk per plant and kernel dry weight per plant (Table 2). Higher yields were influenced by growth characteristics that provide higher results with drip irrigation treatment (Usoh et al., 2017). Moreover, it was added with rice husk mulch and mycorrhiza to help maintain water availability and nutrient uptake for plants. According to Irmak et al. (2022), drip irrigation had a higher grain yield of corn than furrow irrigation. Although the cost of cultivation with the drip irrigation system was 24.92–27.44% higher than furrow irrigation, it was 55.43–58.16% more labor cost efficient than furrow irrigation. Drip irrigation resulted in higher yield, profit (9.87–19.52%), and revenue-cost ratio (6.47–21.74%) than furrow irrigation. According to Sujatha et al. (2023), drip irrigation can be recommended to farmers over furrow irrigation, which could achieve 26.6% water savings over furrow irrigation.

According to Pedroso et al. (2022), corn yields were significantly increased by mycorrhiza application. Mycorrhiza-inoculated corn was shown to exhibit improved osmoregulation capacity, characterized by higher concentrations of soluble sugars and electrolytes. Both of these had clear implications for the potential for higher corn yields. In this research, the effect of mycorrhiza application on furrow irrigation was not well expressed. This was shown by the farmer's practices (furrow irrigation) + mycorrhiza treatment, which was not significantly different from the farmer's practices (furrow irrigation) treatment on weight of cob cornhusk per plant and kernel dry weight per plant. Mycorrhiza treatment on drip irrigation significantly increased the soil-neutral Phosphatase and soil urease activities, which may indicate that drip irrigation significantly increased the effectiveness of N and P in rhizosphere soil (Deng et al., 2022).

The harvest index is the ratio of the economic yield to the total dry weight of plants, which shows the level of efficiency of plants in the process of using photosynthates. The greater the harvest index, the more efficient the plant utilizes photosynthates, so the greater the economic yield. The harvest index value showed a result that was not significantly different between all treatments, which amounted to 0.36. This means that only 36% of photosynthate was used to form the economic yield of plants. The harvest index value was influenced by the size of the kernel dry weight and the total dry weight, but it can also be influenced by the length and rate of plant growth. According to Dini et al. (2018), the harvest index of corn ranges from 0.30–0.40. The value of the harvest index can be determined from the leaf area index, 100 seed weight, and total dry grain yield.

Correlation coefficient of growth components and yield of corn

The growth components have a correlation with each other that eventually affects the yield. The value of Karl Pearson's correlation coefficient helps in finding the correlation between two characters or components (Wamanrao et al., 2020). The stratification of correlation was categorized as negligible (0.00–0.10), weak (0.10–0.39), moderate (0.40–0.69), strong (0.70–0.89),

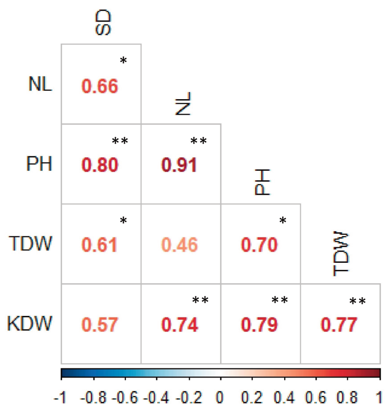

Figure 5. Correlogram of the relationship between growth components and yield of corn

Remark: PH = Plant height, NL = Number of Leaves, SD = Stem Diameter, TDW = Total Dry Weight, KDW = Kernel Dry Weight. Red numbers indicate a positive correlation, sign * = significant different at 5% and sign ** = significant different at 1%.

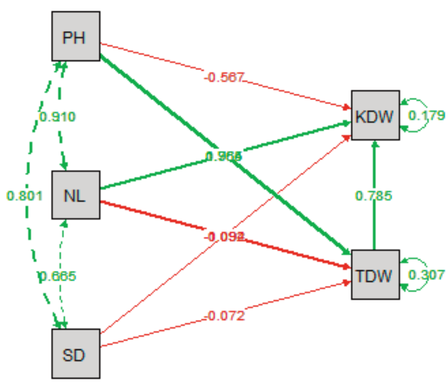

Figure 6. Path analysis diagram of growth components on corn crop yield

Remark: PH = Plant height, NL = Number of Leaves, SD = Stem Diameter, TDW = Total Dry Weight, KDW = Kernel Dry Weight. R^2_1 = 0.69 and R^2_2 = 0.82. Residual effect of path 1 (e_1) = 0.56, residual effect of path 2 (e_2) = 0.42.

and very strong (0.90–1.00). The correlation coefficient of nearer -1 means a total negative linear correlation, 0 means no correlation, and +1 means a total positive correlation (Schober et al., 2018).

Figure 5 shows the correlogram of the relationship between growth components, including stem diameter, number of leaves and plant height at 6 WAP, total dry weight, and yield of corn (kernel dry weight). Number of leaves was significantly correlated with stem diameter. Plant height had a positive and significantly strong correlation with stem diameter and number of leaves. The higher the plant height, the larger the stem diameter and the number of leaves. Total dry weight was significantly correlated with stem diameter and plant height. Number of leaves at 6 WAP (r = 0.74**, p-value ≤ 0.01), plant height at 6 WAP (r = 0.79**, p-value ≤ 0.01), and total dry weight (r = 0.77**, p-value ≤ 0.01) were significantly correlated with kernel dry weight, while stem diameter at 6 WAP (0.57) was not significantly correlated with kernel dry weight. A highly significant correlation between the growth components associated with yield indicated that every one-unit increase in one of the components leads to a one-unit increase in the other associated components.

Path analysis of growth components and yield of corn

Path coefficient (β) analysis is carried out to study the direct and indirect effects of independent variables on the dependent variable (Wamanrao et al., 2020). Results of path coefficient analysis of all traits or components to yields are given in Figure 6. Plant height, number of leaves, and stem diameter acted as independent variables, while kernel dry weight acted as dependent variable. Total dry weight as an intervening variable acted as a mediating variable between the independent variables and the dependent variable (yield).

The results of path coefficient analysis revealed that the number of leaves (β = 0.96, p-value ≤ 0.05) and total dry weight (β = 0.79, p-value ≤ 0.05) had a positive direct effect on kernel dry weight (Figure 6). The number of leaves exhibited the highest direct positive effect on kernel dry weight (β = 0.96). Plant height (β = -0.57) and stem diameter (β = -0.09) had a negative direct effect on kernel dry weight. Plant height had a positive indirect effect on kernel dry weight through the total dry weight. This implies that higher kernel dry weight is predominately attributed to the direct effect of the number of leaves (β = 0.96, p-value ≤ 0.05) and the indirect effect of plant height through the total dry weight (β = 1.38, p-value ≤ 0.05), which these results were confirmed from the correlation study data (Figure 5).

Yield is such a complex quantitative trait; hence multiple traits need to be considered for its improvement. The correlation did not depict a clear relationship between traits, and the path coefficient serves as an important tool for showing the direct and indirect effects of independent variables on dependent variables (Rachana et al., 2021). The correlation and path coefficient analysis results strongly indicated that the number of leaves, plant height, and total dry weight should be considered important plant growth variables to produce high kernel dry weight. High kernel dry weight can be obtained by best practices treatment (Drip Irrigation + Rice Husk + Mycorrhiza).

CONCLUSIONS

Best practices treatment (Drip Irrigation + Rice Husk + Mycorrhiza) is effective in corn management practices based on growth variables (plant height, stem diameter, number of leaves, leaf dry weight, root dry weight, and total dry weight) and yield (weight of cob with cornhusk and kernel dry weight). Best practice effectively suppressed weed growth by 163.63% than Farmers' Practices (Furrow Irrigation) + Mycorrhiza and 281.81% than Farmers' practices (Furrow Irrigation), and it increased the kernel dry weight by 14.22% than Farmers' Practices (Furrow Irrigation) + Mycorrhiza and 22.91% than Farmers' practices (Furrow Irrigation). The number of leaves, plant height, and total dry weight should be considered important plant growth variables to produce high kernel dry weight.

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REFERENCES

Agbodjato, N.A., Assogba, S.A., Babalola, O.O., Koda, A.D., Aguégué, R.M., Sina, H., Dagbénonbakin, G.D., Adjanohoun, A., and Baba-Moussa, L. (2022). Formulation of Biostimulants Based on Arbuscular Mycorrhizal Fungi for Maize Growth and Yield. *Frontiers in Agronomy*, 4, pp. 1–15.

Ahmadi, S.H., Ghasemi, H., and Sepaskhah, A.R. (2020). Rice Husk Biochar Influences Runoff Features, Soil Loss, and Hydrological Behavior of A Loamy Soil in a Series Of Successive Simulated Rainfall Events. *Catena*, 192, pp. 1–13.

Alhashimi, A., AL-Huqail, A., Hashem, M., Bakr, B., Fekry, W., Abdel-Aziz, H., Hamdy, A., Abdelraouf, R., and Fathy, M. (2023). Using Deficit Irrigation Strategies and Organic Mulches for Improving Yield and Water Productivity of Mango under Dry Environment Conditions. *Agriculture*, 13(7), pp. 1–21.

Araujo, D.F., Costa, R.N., and Mateos, L. (2019). Pros and Cons of Furrow Irrigation on Smallholdings in Northeast Brazil. *Agricultural Water Management*, 221, pp. 25–33.

Aristya, V.E., and Samijan, S. (2022). The Yield Gap Maize under Intensive Cropping System in Central Java. *Planta Tropika: Jurnal Agrosains (Journal of Agro Science)*, 10(1), pp. 1–12.

Artiola, J. F. (1991). Nonuniform leaching of nitrate and other solutes in a furrow-irrigated, sludge amended field. *Communications in Soil Science and Plant Analysis*, 22(9–10), pp. 1013–1030.

Asres, L.A. (2023). Alternative Techniques of Irrigation Water Management for Improving Crop Water Productivity. *Reviews in Agricultural Science*, 11, pp. 36–53.

Begum, N., Qin, C., Ahanger, M. A., Raza, S., Khan, M. I., Ashraf, M., Ahmed, N., and Zhang, L. (2019). Role of Arbuscular Mycorrhizal Fungi in Plant Growth Regulation: Implications in Abiotic Stress Tolerance. *Frontiers in Plant Science*, 10(September), pp. 1–15.

Bharati, S., Joshi, B., Dhakal, R., Paneru, S., Chandra Dhakal, S., and Raj Joshi, K. (2019). Effect of Planting Depth and Mulching Materials on Yield and Yield Attributes of Potato in Dadeldhura, Nepal. *Acta Scientific Agriculture*, 3(10), pp. 131–140.

Bhasker, P., Singh, R. K., Gupta, R. C., Sharma, H. P., and Gupta, P. K. (2018). Effect of drip irrigation on growth and yield of onion (*Allium cepa* L.). *Journal of Spices and Aromatic Crops*, 27(1), pp. 32–37.

Buzo, F. de S., Garcia, N.F.S., Garé, L.M., Gato, I.M.B., Martins, J.T., Martins, J.O.M., Morita, P.R. de S., Silva, M.S.R. de A., Sales, L.Z. de S., Nogales, A., Rigobelo, E.C., and Arf, O. (2022). Phosphate Fertilization and Mycorrhizal Inoculation Increase Corn Leaf and Grain Nutrient Contents. *Agronomy*, 12(7), pp. 1–14.

Compant, S., Samad, A., Faist, H., and Sessitsch, A. (2019). A Review on the Plant Microbiome: Ecology, Functions, and Emerging Trends in Microbial Application. *Journal of Advanced Research*, 19, pp. 29–37.

Deng, Q., Wu, Y., Zhao, X., Qiu, C., Xia, S., Feng, Y., and Liu, H. (2022). Influence of Different Irrigation Methods on the Alfalfa Rhizosphere Soil Fungal Communities in an Arid Region. *PLoS ONE*, 17(6), pp. 1–18.

Dini, A.Z., Yuwariah, Y., Yulianto, W.F., and Ruswandi, D. (2018). Growth and Yield of Maize (*Zea mays* L.) under Intercropping with Sweet Potato (*Ipomoea batatas* (L.) Lam) in Arjasari Bandung Regency. *Jurnal Agrotek Indonesia*, 3(2), pp. 113–120.

Farjon, G., Itzhaky, Y., Khoroshevsky, F., and Bar-Hillel, A. (2021). Leaf Counting: Fusing Network Components for Improved Accuracy. *Frontiers in Plant Science*, 12, pp. 1–12.

Henry, W.B. and Krutz, L.J. (2016). Water in Agriculture: Improving Corn Production Practices to Minimize Climate Risk and Optimize Profitability. *Current Climate Change Reports*, 2(2), pp. 49–54.

Hsieh, C.Y., Fang, S.L., Wu, Y.F., Chu, Y.C., and Kuo, B.J. (2021). Using Sigmoid Growth Curves to Establish Growth Models of Tomato and Eggplant Stems Suitable for Grafting in Subtropical Countries. *Horticulturae*, 7(12), 537.

Huey, C.J., Gopinath, S.C.B., Uda, M.N.A., Zulhaimi, H.I., Jaafar, M.N., Kasim, F.H., and Yaakub, A.R.W. (2020). Mycorrhiza: A Natural Resource Assists Plant Growth under Varied Soil Conditions. *3 Biotech*, 10(5), pp. 1–9.

Irmak, S., Mohammed, A.T., and Kukal, M.S. (2022). Maize Response to Coupled Irrigation and Nitrogen Fertilization Under Center Pivot, Subsurface Drip and Surface (Furrow) Irrigation: Growth, Development and Productivity. *Agricultural Water Management*, 263, pp. 1–53.

Jalal, A., Oliveira, C.E. da S., Rosa, P.A.L., Galindo, F.S., and Teixeira Filho, M.C.M. (2023). Beneficial Microorganisms Improve Agricultural Sustainability under Climatic Extremes. *Life*, 13(5), pp. 1–23.

Karimi, B., Cahurel, J.Y., Gontier, L., Charlier, L., Chovelon, M., Mahé, H., and Ranjard, L. (2020). A Meta-analysis of the Ecotoxicological Impact of Viticultural Practices on Soil Biodiversity. *Environmental Chemistry Letters*, 18(6), pp. 1947–1966.

Koca, Y.O., and Erekul, O. (2016). Changes of Dry Matter, Biomass and Relative Growth Rate with Different Phenological Stages of Corn. *Agriculture and Agricultural Science Procedia*, 10, pp. 67–75.

Liu, M., Wang, G., Liang, F., Li, Q., Tian, Y., and Jia, H. (2022). Optimal Irrigation Levels Can Improve Maize Growth, Yield, and Water Use Efficiency under Drip Irrigation in Northwest China. *Water (Switzerland)*, 14(23), 3822.

Ma, H., Yang, T., Niu, X., Hou, Z., and Ma, X. (2021). Sound Water And Nitrogen Management Decreases Nitrogen Losses from a Drip-Fertigated Cotton Field in Northwestern China. *Sustainability (Switzerland)*, 13(2), pp. 1–13.

Ma, J., Wang, W., Yang, J., Qin, S., Yang, Y., Sun, C., Pei, G., Zeeshan, M., Liao, H., Liu, L., and Huang, J. (2022). Mycorrhizal Symbiosis Promotes the Nutrient Content Accumulation and Affects the Root Exudates in Maize. *BMC Plant Biology*, 22(1), pp. 1–13.

Miceli, A., Vetrano, F., Torta, L., Esposito, A. and Moncada, A. (2023). Effect of Mycorrhizal Inoculation on Melon Plants under Deficit Irrigation Regimes. *Agronomy*, 13(2), pp. 1–22.

Muslimah, Y., Lizmah, S. F., Harahap, E. J., Jasmi, and Alfatah, M. (2022). The effect of drip irrigation on the growth of two varieties of sweet corn (*Zea mays* L.). *IOP Conference Series: Earth and Environmental Science*, 977(1), pp. 1–8.

Nasution, I.S., Satriyo, P., Ichwana, Yolanda, S., and Alma, A. (2021). Non-destructive Measurement of Leaf Area and Leaf Number of Hydroponic Pak-Choy Plants (*Brassica rapa*). *IOP Conference Series: Earth and Environmental Science*, 644(1), pp. 1–9.

Nurjanah, U., Setyowati, N., Prasetyo, P., Fahrurrozi, F., and Muktamar, Z. (2021). Weed Growth and Sweet Corn Yield as Affected by Planting Patterns and Mulch Types in Organic Farming Practice. *IOP Conference Series: Earth and Environmental Science*, 694(1), pp. 1–7.

Pedroso, R.M., Medeiros, C.A., Ometto, A., Paes, V., de Andrade, E.F., Inman, S., da Silva, J.R., and Pedroso, G.M. (2022). In-furrow Application of Arbuscular Mycorrhizal Fungi Propagules Enhanced Yields, Plant Vigor, and Biomass Accumulation of Soybeans (*Glycine max*) and Maize (*Zea mays*). *Australian Journal of Crop Science*, 16(5), pp. 657–664.

Pérez-Harguindeguy, N., Díaz, S., Garnier, E., Lavorel, S., Poorter, H., Jaureguiberry, P., Bret-Harte, M.S., Cornwell, W.K., Craine, J.M., Gurvich, D.E., Urcelay, C., Veneklaas, E.J., Reich, P.B., Poorter, L., Wright, I.J., Ray, P., Enrico, L., Pausas, J.G., De Vos, A.C., Buchmann, N., Funes, G., Quétier, F., Hodgson, J.G., Thompson, K., Morgan, H.D., Ter Steege, H., Van Der Heijden, M.G.A., Sack, L., Blonder, B., Poschlod, P., Vaieretti, M. V., Conti, G., Staver, A.C., Aquino, S. and Cornelissen, J.H.C. (2013). New Handbook for Standardised Measurement of Plant Functional Traits Worldwide. *Australian Journal of Botany*, 61(3), pp. 167–234.

Pop-Moldovan, V., Vârban, R., Corcoz, L., Pleșa, A., Stoian, V., and Vidican, R. (2021). Divergence in Corn Mycorrhizal Colonization Patterns due to Organic Treatment. *Plants*, 10(12), pp. 1–17.

Pusparini, P.G., Yunus, A., and Harjoko, D. (2018). Dosis Pupuk NPK Terhadap Pertumbuhan dan Hasil Jagung Hibrida. *Agrosains: Jurnal Penelitian Agronomi*, 20(2), pp. 28–33.

Rachana, P., Binju, M., Suprava, A., K.C., B., Rishav, P., Rashmi, R., Bishnu, B., Pritika, N., Kushal, B., and Ram, P.M. (2021). Correlation and Path Coefficient Analysis of Yield in Wheat: a Review. *Russian Journal of Agricultural and Socio-Economic Sciences*, 113(5), pp. 121–127.

Rai, R.K., Singh, V.P., and Upadhyay, A. (2017). Irrigation Methods. In *Planning and Evaluation of Irrigation Projects*, pp. 353–363.

Ramli. (2017). The Effect of Rice Husk Mulch's Dosage on the Production Growth of Some Cabbage Varieties (*Brassica oleracea* L.). *IOSR-JAVS*, 10(8), 38–41.

Ranilla, L.G. (2020). The Application of Metabolomics for the Study of Cereal Corn (*Zea mays* L.). *Metabolites*, 10(8), pp. 1–24.

Ranjan, S. and Sow, S. (2021). Drip Irrigation System for Sustainable Agriculture. *Agriculture and Food: E-Newsletter*, pp. 2–5.

Rustikawati, Suprijono, E., Murcitro, B. G., Herison, C., and Sitohang, S. J. (2022). Amendment of mycorrhizae and its residual effect on growth and yield of maize (*Zea mays*) hybrids in coastal land. *Biodiversitas*, 23(11), pp. 5600–5605.

Salahudeen, A.B., and Sadeeq, J.A. (2018). Use of Rice Husk and Sawdust as Composite Mulching Material for Onion. In *Use of rice husk and sawdust as composite mulching material for onion*, pp. 1–4.

Saranya, P., Sri Gayathiri, C.M. and Sellamuthu, K.M. (2018). Potential Use of Rice Husk Ash for En*hancing Growth of Maize (Zea mays). International Journal of Current Microbiology and Applied Sciences*, 7(03), pp. 899–906.

Schober, P., Boer, C., and Schwarte, L.A. (2018). Correlation coefficients: Appropriate Use and Interpretation. *Anesthesia and Analgesia*, 126(5), pp. 1763–1768.

Seeda, M.A.A., Yassen, A.A., El-Nour, E.A.A.A., and Hammad, S.A. (2020). Management of Furrow Irrigation Technology and Its Risk Assessments: A review. *Middle East Journal of Applied Sciences*, 10(04), pp. 590–616.

Sharma, S., Basnet, B., Bhattarai, K., Sedhai, A., and Khanal, K. (2023). The Influence of Different Mulching Materials on Tomato's Vegetative, Reproductive, and Yield in Dhankuta, Nepal. *Journal of Agriculture and Food Research*, 11, pp. 1–7.

Sheikh-Assadi, M., Khandan-Mirkohi, A., Taheri, M.R., Babalar, M., Sheikhi, H., and Nicola, S. (2023). Arbuscular Mycorrhizae Contribute to Growth, Nutrient Uptake, and Ornamental Characteristics of Statice (*Limonium sinuatum* [L.] Mill.) Subject to Appropriate Inoculum and Optimal Phosphorus. *Horticulturae*, 9(5), pp. 1–16.

Siyal, A. A., Bristow, K. L., and Šimůnek, J. (2012). Minimizing nitrogen leaching from furrow irrigation through novel fertilizer placement and soil surface management strategies. *Agricultural Water Management*, 115(3), pp. 242–251.

Siyal, A. A., and Siyal, A. G. (2013). Strategies to Reduce Nitrate Leaching under Furrow Irrigation. *International Journal of Environmental Science and Development*, 4(4), pp. 431–434.

Spencer, G.D., Krutz, L.J., Falconer, L.L., Henry, W.B., Henry, C.G., Larson, E.J., Pringle, H.C., Bryant, C.J., and Atwill, R.L. (2019). Irrigation Water Management Technologies for Furrow-Irrigated Corn that Decrease Water Use and Improve Yield and On-Farm Profitability. *Crop, Forage & Turfgrass Management*, 5(1), pp. 1–8.

Sudprasert, S., and Sankaewthong, S. (2018). Utilization of rice husks in a water-permeable material for passive evaporative cooling. *Case Studies in Construction Materials*, 8, pp. 51–60.

Sujatha, H.T., Sangadi, S.S., Yenagi, B.S., and Meena, R.P. (2023). Effect of Drip Irrigation Regimes on Growth, Yield and Economics of Maize (*Zea mays*) Genotypes. *The Indian Journal of Agricultural Sciences*, 93(2), pp. 163–168.

Suryawanshi, P. K. (2022). *Fundamentals of Agronomy - I*. [ebook] Chhattisgarh: Sankalp Publication. Available at https://books.google.co.id/books/about/Fundamentals_Of_Agronomy_1.html?id=JrJuEAAAQBAJ&redir_esc=y [Accessed 14 September 2023].

Suwandi. (2022). *Laporan Kinerja Direktorat Jenderal Tanaman Pangan*. Jakarta, Indonesia: Kementerian Pertanian.

Tabrani, H., and Saiful, S.A. (2023). Management of Hybrid Corn Technology Application in Gorontalo. *Journal of Public administration and Government*, 5(1), pp. 50–58.

Thiyageshwari, S., Gayathri, P., Krishnamoorthy, R., Anandham, R., and Paul, D. (2018). Exploration of Rice Husk Compost as an Alternate Organic Manure to Enhance the Productivity of Blackgram in Typic Haplustalf and Typic Rhodustalf. *International Journal of Environmental Research and Public Health*, 15(2), pp. 1–14.

Torres, N., Yu, R., and Kaan Kurtural, S. (2021). Inoculation with Mycorrhizal Fungi and Irrigation Management Shape the Bacterial and Fungal Communities and Networks in Vineyard Soils. *Microorganisms*, 9(6), pp. 1–22.

Usoh, G.A., Nwa, E.U., Okokon, F.B., Nta, S.A., and Etim, P.J. (2017). Effects of Drip and Furrow Irrigation Systems Application on Growth Characteristics and Yield of Sweet Maize under Sandy Loam Soil. *International Journal of Scientific Engineering and Science*, 1, pp. 22–25.

Wamanrao, A.N., Kumar, V., and Meshram, D. (2020). Correlation and Path Coefficient Analysis of Grain Yield and its Growth Components in Soybean (*Glycine max*. L.). *International Journal of Current Microbiology and Applied Sciences*, 9(3), pp. 2445–2451.

Wang, X., Singh, D., Marla, S., Morris, G. and Poland, J. (2018). Field-based High-throughput Phenotyping of Plant Height in Sorghum Using Different Sensing Technologies. *Plant Methods*, 14(1), pp. 1–16.

Wang, Y., Li, S., Cui, Y., Qin, S., Guo, H., Yang, D., and Wang, C. (2021). Effect of Drip Irrigation on Soil Water Balance and Water Use Efficiency of Maize in Northwest China. *Water (Switzerland)*, 13(217), pp. 1–13.

Yang, W., Jiao, Y., Yang, M., Wen, H., Gu, P., Yang, J., Liu, L., and Yu, J. (2020). Minimizing soil nitrogen leaching by changing furrow irrigation into sprinkler fertigation in potato fields in the Northwestern China Plain. *Water (Switzerland)*, 12(8), pp. 1–15.

Yang, P., Wu, L., Cheng, M., Fan, J., Li, S., Wang, H., and Qian, L. (2023). Review on Drip Irrigation: Impact on Crop Yield, Quality, and Water Productivity in China. *Water (Switzerland)*, 15(9), pp. 2–18.