Implementation of Supplementary Water Irrigation and Rice Husk for Climate Change Adaptation and Improving Soil Quality in Dry Land, Gunungkidul

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Abstract. Dry land in Gunungkidul is the land that depends on rainfall as the main water source to the crops. This research aimed to evaluate the implementation of supplementary water irrigation and rice husk for improving soil quality. The study conducted at dry land of Wonosari-Gunungkidul on June-Sept 2019. Experimental Design used Randomized Completely Block and replicated four times. The treatments were frequency of irrigation, namely F1 (1 times), F2 (2 times), F3 (3 times) a week, and application of soil amendment, namely: M1 (without mulch), M2 rice straw 4 ton.ha-1), M3 (rice husks 4 ton.ha-1), M4 (straw mulch + rice husk 4 ton.ha-1). The result of study showed that applying straw much and rice husk plus supplementary water irrigation two times a week was able to provide the highest corn production (7.46 ton.ha-1) and was not significantly different to the irrigation three times a week and showed an increased yield of corn 52.56% compared to control (watering once a week and without mulch/rice husk). Applying straw and rice husk can be improved the chemical soil properties (increasing water holding capacity,C-organic, P and K available and CEC).The financial farming of BC ratio reached 2.25 and increased 144.56% compare to control treatment.

1 Introduction

The most dominant land use for agriculture in Gunungkidul Regency is in the dry land condition that mainly are in the form of rainfed and calcareous land. The calcareous land is one of the dry land areas that are widely spread in almost all regions on Gunungkidul [1]. Dry land in Gunungkidul Regency is quite potential to be developed as agricultural land because it has an area about 66,827 hectares or about 46.63 percent of the agricultural land on the Yogyakarta Special Region Province. Dry land is the land that only depends on rainfall

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as the main water source to fulfill the water needs by crops, including corn. Gunung Kidul Regency based on topography and land conditions is divided into 3 zonings , namely Batur Agung, Ledok Wonosari and the Thousand Mountains. While Wareng village, Wonosari District as the research location, is included in the Ledok Wonosari zone. According to Kusumayudha [2] the Ledok Wonosari zone is an area that has groundwater and river sources, which will experience drought in the dry season. The unfavourable conditions and climate are the main problems for the local community in providing the food needs and animal feed. One way to overcome the problems faced in dry land is to increase land productivity and create supplementary water irrigation in the dry land.

Supplemental irrigation is the administration of water as a complementary if the rainfall is not sufficient to compensate for water loss plants caused by evapotranspiration or plant water needs [3], [4]. Supplemental irrigation aims to provide water that plants need at the time, volume, and interval right. By using irrigation technology supplements, growing season (for annuals) in most parts of Gunungkidul area is not limited only during the rainy season, but can be extended until the middle of the dry season. This matter can be possible because about 52% of Gunungkidul's territory has an annual rainfall of < 2,200 mm. If rain harvesting technology, save water, and irrigation technical also socio-economic supplements can be applied, then the problem of water shortage, as due to climate change, will be overcome.

Irrigation plays an increasingly important role in the area of drought-prone agriculture. Irrigation systems that applied today are generally still traditional, which includes the distribution and use of water, and still pay less attention to the balance between the amount of water supplied and plant water requirements. Non-technical irrigation system tends to waste water usage, reduce the efficient use of nutrients, and causes degradation of land due to inundation, especially if the system irrigation is not combined with drainage [5]. This means that the use of irrigation water that does not right can not only waste money, resources of water, energy, and time but can also destroying land resources.

In the agricultural sector, the impact of climate change can reduce production and productivity food commodities [6], [7]. Therefore, efforts to reduce the burden of loses due to climate change (drought, flooding, and extreme climatic conditions) need to be anticipated by recognizing and understanding climate behaviour and make appropriate adjustments to obtain optimal results[8], [9].

Soil organic carbon depletion, increased emission of greenhouse gases, and global warming are major concerns nowadays. One of the most recent measures used to enhance the carbon sequestration in soils is addition of biochar. Biochar is produced through a pyrolysis process, when tissues of biological origin are burned or charred in the absence of, or at low levels, of oxygen [10]. Biochar has been shown to improve chemical, physical, and biological properties of soils [11], and enhance plant growth and development [12]. Biomass such as crop residues, woody material, green wastes, animal manures and agricultural wastes, such a rice husks, can be used for biochar production. Conversion of wastes such as rice husk into biochar through pyrolysis can result in advantages such as energy production, sustainable waste recycling, carbon sequestration, improvement of soil quality, increased soil water holding capacity and better plant growth. Other researchers stated [13, 14], that application of biochar rice husk can reduce the supplies of fertilizer, improved activities of microbes in the soil, the emission of greenhouse gases in fields are reduced, modification of drought, organic carbon content in soils are increased, increase soil water-holding capacity and thus the physical soil properties are improved.

Based on the description above then the objective of this study is to evaluate the implementation of supplementary water irrigation and rice straw mulch also rice husk biochar on the improving soil quality in dry land and evaluate the financial farming system on the corn cultivation.

2 Material and Method

The research was conducted at dry land of Wareng village, Wonosari District Gunungkidul Regency on June - September 2019. The location has an altitude 198 m above sea level. The minimum temperature about 26^{O}C and maximum temperature about 32^{O}C.The average of annually rainfall was 1958 mm / year. The land condition was rather flat topography with the slope about 3-10%. Water source depend on the rainfall plus supplementer water irrigation from 3 (three) deep bore well. The soil pH in the study area was classified as slightly alkaline (pH 7.32-7.76), while the C-organic content and N-total were 1.16% and 0.18 %, C / N ratio was 7.25 (classified as low category). P_2O_5 total was 155.3 mg/100g whila K_2O total was 36.7 mg/100g. CEC soil was 40.85 me/ 100 g soil. The type of soil was classified as Inceptisols.

The material used in this research area were the corn seed of Bisi 2 variety, inorganic fertilizer used : Nitrogen fertilizer (Urea: 46% N), Potassium fertilizer (KCl: 60% K_2O), Phosphorus fertilizer (SP-36: 36% P_2O_5), while other materials were rice straw as mulch, rice hush, biofertilizer *Agrofit* and biopesticides.

The tools that used were tractors, submersible pumps, long hoses, hoes, sprayers, measuring cups, meters tool, stationery, camera, thermometers, analytical balancing scales, biomass scales, sacks, buckets volume 15 litre and 20 litre, plastics, sickles and other corn cultivation tools commonly used by farmer community.

The Experimental Design was used Randomized Complete Block Design (RCBD), therefore the total treatments were 3 x 4 =12 treatments and replicated 4 times. The treatments application were the frequency of irrigation, namely F1 (once a week), F2 (two times a week), F3 (three times a week), and the application of soil amendment material, namely: M1 (without applied rice straw mulch), M2 (applying rice straw mulch 4 ton/ha), M3 (applying rice husk 4 ton/ha), M3 (applying rice straw mulch + rice husk 4 ton/ha).

The experimental data were processed by the statistical method used analysis of variance (Anova). at significance $P < 0.05$, which using SAS Program version 9.0, then proceeded by Duncan's Multiple Range Test (DMRT) on 5 levels of significance to compare the mean values of the treatments, if a significant difference between treatments was detected. All of the analysis statistical data followed by the agricultural data analyzing guidance [15].

3 Result and Discussion

3.1 The effect of supplementary irrigation and soil amendment on the corn growth

The results of observations of corn growth, including plant height and number of leaves on 25 and 65 after planting was presented in Table 1 below.

Based on Table 1, it was shown that the treatment on irrigation 2 times a week + straw mulch + rice husk biochar indicated the highest growth as well as the treatment irrigation 3 times a week + rice straw + rice husk showed the same results compared to other treatments and control. The amount or frequency of irrigation water added to corn plantings have a positive effect on corn growth compared to only the application of rice straw mulch and application of rice husk biochar. This is in accordance with [16], which stated that water added via a technique irrigation in dry land is necessary taking into account the rainfall conditions limited. Common irrigation techniques applied by farmers is surface irrigation. Furthermore [17], also stated that water deficit occurs in plants every time transpiration exceeds water absorption. This matter is caused by plant loss of water excessive but absorption from the soil reduced, or both of them.

Table 1. The observation of plant heigh and number of corn leaves

No.	Treat ment Code	Description of treatments	Observation Plant height		The number of corn leaves	
			25 DAP	65 DAP	25 DAP	65 DAP
1	F1M1	Irrigation 1 x a week without mulch	55.02 b	202.78 d	5.8 d	14.2 d
2	F1M2	Irrigation 1 x a week + rice straw	58.18 c	207.14 d	6.4 cd	14.9 d
3	F1M3	Irrigation 1 x a week + rice husk	60.68 bc	214.36 c	6.9 cd	15.8 c
4	F1M4	Irrigation 1 x a week + rice straw + rice husk	59.94 bc	218.28 bc	7.9 c	15.2 cd
5	F2M1	Irrigation 2 x a week – without mulch	65.52 b	212.64 c	7.2 c	16.1 b
6	F2M2	Irrigation 2 x a week + rice straw	67.37 b	216.79 c	9.5 b	16.7 b
7	F2M3	Irrigation 2 x a week + rice husk	66.72 b	225,14 b	9.8 b	17.8 ab
8	F2M4	Irrigation 2 x a week + rice straw + rice husk	78.32 a	230.52 a	10.9 a	18.3 a
9	F3M1	Irrigation 3 x a week – no mulch	62.93 bc	220.14 bc	8.2 c	16.6 b
10	F3M2	Irrigation 3 x a week + rice straw	68.57 b	214.64 ab	8.9 bc	16.4 b
11	F3M3	Irrigation 3 x a week + rice husk	70.33 b	228.32 b	9.7 b	17.6 ab
12	F3M4	Irrigation 3 x a week + rice straw + rice husk	77.38 a	234.87 a	10.8 a	18.4 a
CV (%)			8.52	9,46	10.14	9.78

Noted: The numbers accompanied by the same letter in one column are not significantly different based on DMRT of 5% level
DAP = Day After Planting Corn

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Table 2. The observation of yield components of corn

No.	Treatment Code	Description of treatments	Weight of corn cobs without husk (gr)	The Cob diameter (cm)	The Cob length (cm)
1	F1M1	Irrigation 1 x a week – without mulch	176.98 d	15.74 d	17.86 c
2	F1M2	Irrigation 1 x a week + rice straw	180.26 d	15.96 d	17.98 bc
3	F1M3	Irrigation 1 x a week + rice husk	187.52 c	16.27 c	18.13 b
4	F1M4	Irrigation 1 x a week + rice straw + rice husk	190.64 c	16.52 c	18.24 b
5	F2M1	Irrigation 2 x a week – without mulch	186.82 cd	16.83 bc	18.05 bc
6	F2M2	Irrigation 2 x a week + rice straw	195.71 bc	16.68 c	18.52 b
7	F2M3	Irrigation 2 x a week + rice husk	192.34	17.06 b	18.64 ab
8	F2M4	Irrigation 2 x a week + rice straw + rice husk	213.46 a	17.85 a	19.28 a
9	F3M1	Irrigation 3 x a week – without mulch	197.25 bc	16.91 bc	18.16 b
10	F3M2	Irrigation 3 x a week + rice straw	203.52 b	17.13 ab	18.69 ab
11	F3M3	Irrigation 3 x a week + rice husk	209.17 b	17.09 b	18.83 ab
12	F3M4	Irrigation 3 x a week + rice straw + rice husk	212.83 a	17.91 a	19.32 a
CV (%)			10.62	10.83	9.74

Noted : The numbers accompanied by the same letter in one column are not significantly different based on DMRT 5% level

3.2 The effect of irrigation and soil ameliorant on the corn yield

The results of the analysis of variance in the treatment applied were shown in Tables 2 and 3 below. The treatment of giving irrigation water twice a week plus the application of rice straw and rice husk biochar 4 ton/ ha was not significantly different from irrigation water three time a week plus the application of rice straw and rice husk and it was significantly different from other treatment. The treatment with irrigation once a week gave the same results as irrigation twice a week plus application only rice straw or rice husk. This indicates that the application of ameliorants in marginal dry land will affect soil moisture content thereby affecting the productivity of corn plants. This is in accordance with the statement of [18], which prove that the low irrigation discharge and the short reach of the irrigation area cause the time needed by farmers to irrigate their land is relatively long, so it is confiscating time needed to do other work. Therefore, the solution way is to increase the frequency of the amount of irrigation water provided by adding ameliorant material as biochar rice husk and rice straw mulch, which this material was as agricultural waste and available abundance in the site location.

Moreover, another researcher give statement [19], that rice husk charcoal contains high content of silica elements, namely 87–97% which can increase resistance plants against imbalance nutrients, strengthen the stem so lodging resistant plants, reducing abiotic and biotic stresses so that they can strengthening tissues, increasing water holding capacity and retaining soil moisture from drought stress.

Table 3. The observation of yield of corn

No.	Treatment Code	Description of treatments	The weight of biomass (kg/ha)	The weight of 100 grains (gr)	The yield of corn husk (kg/ha)
1	F1M1	Irrigation 1 x a week – without mulch	10.46 d	25.47 c	5.83 d
2	F1M2	Irrigation 1 x a week + rice straw	10.93 d	25.89 bc	6.16 d
3	F1M3	Irrigation 1 x a week + rice husk	11.19 cd	25.99 b	6.87 cd
4	F1M4	Irrigation 1 x a week + rice straw + rice husk	11.48 c	25.92 b	7.38 b
5	F2M1	Irrigation 2 x a week – without mulch	11.34 c	26.05 b	7.14 c
6	F2M2	Irrigation 2 x a week + rice straw	11.72 bc	26.34 ab	7.42 b
7	F2M3	Irrigation 2 x a week + rice husk	12.41 b	26.71 a	7.90 b
8	F2M4	Irrigation 2 x a week + rice straw + rice husk	12.87 a	26.94 a	7.85 a
9	F3M1	Irrigation 3 x a week – without mulch	11.85 bc	26.13 ab	7.41 b
10	F3M2	Irrigation 3 x a week + rice straw	11.96 bc	26.38 ab	7.68 ab
11	F3M3	Irrigation 3 x a week + rice husk	12.32 b	26.82 a	7.82 ab
12	F3M4	Irrigation 3 x a week + rice straw + rice husk	12.94 a	26.98 a	7.87 a
CV (%)			11.27	9.58	10.82

Noted: The numbers accompanied by the same letter in one column are not significantly different based on DMRT 5% level

3.3 The effect of supplementary irrigation and soil amendment on chemical soil properties

Based on Table 4 below, it was shown that increasing the frequency of watering or irrigation from borehole sources and the combination of application rice straw as mulch plus biochar rice husk biochar did not increase soil pH significantly. Whereas in organic C and total N

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content there was an increase of 26.27% for organic C and 58.82% for N total after watering at least 2 times a week and addition of soil ameliorant materials as rice straw 3 tons / ha and biochar rice husk 4 tons/ha. There are also happen to the content of total P_2O_5, K_2O and soil CEC levels, which were increased of 20.92%, 36.81% and 29.46% respectively by the application of watering field as 2 times a week plus straw mulch and biochar rice husk. This was indicated that application of rice straw and rice husk biochar in dry land of Gunungkidul can improve the quality of paddy fields which are quite intensive in planting crops. The present study reported [20], that application of rice straw incorporation with rice husk biochar can be increased soil organic matter content and cation exchange capacity in the soil.

Furthermore, improvement of soil properties and plant growth enhancement can be achieved as a result of application of biochar amendment to the soil field [21]. Moreover other researcher give the statement, [22], that conversion of agricultural wastes such as rice husk into biochar through pyrolysis can result in advantages such as energy production, sustainable waste recycling, carbon sequestration, improvement of soil quality, and better corn plant growth in the marginal dry land.

Table 4. The improvement of chemical soil properties after the applied treatment

No.	Treatment Code	pH soil	C-org (%)	N-total (%)	P_2O_5 total (mg/ 100g)	K_2O total (mg/ 100g)	CEC soil (me/ 100g)
1	F1M1	7.44	1.18	0.17	156.8	36.4	42.35
2	F1M2	7.41	1.22	0.19	162.4	39.7	40.62
3	F1M3	7.42	1.31	0.22	160.1	42.5	47.49
4	F1M4	7.58	1.30	0.24	168.7	46.1	48.73
5	F2M1	7.50	1.24	0.18	176.2	45.8	49.63
6	F2M2	7.54	1.32	0.20	172.4	43.4	50.78
7	F2M3	7.60	1.49	0.27	189.6	49.8	54.83
8	F2M4	7.57	1.42	0.25	184.3	45.2	53.42
9	F3M1	7.50	1.25	0.23	165.7	45.7	46.64
10	F3M2	7.55	1.37	0.24	169.3	42.9	48.17
11	F3M3	7.59	1.46	0.26	187.6	48.2	52.86
12	F3M4	7.58	1.48	0.24	185.5	45.3	51.19
CV (%)		12.54	10.83	11.27	12.36	10.75	11.48

3.4 The analysis of financial farming system by applying soil amendment and supplementary irrigation

On Table 5, it was shown that the treatment F1M1 (control), which giving the irrigation 1 time a week without mulch and treatment F1M3, giving irrigation 2 times a week + rice husk were had BC ratio below 1, while others treatment had above 1.0 and RC ratio above 2.0. This indicated that marginal dry land on Wonosari, Gunungkidul was not sufficient to the water, then it was affected to the corn growth and the yield. This condition is related to the research of [23], which stated that the yield and biochemical composition of a corn plant mainly depends on growth conditions, which is controlled by the processes to cellular water uptake and markedly affected by water availability.

Furthermore, application of biochar rice husk and combine with enough watering to the corn plant can improves crop productivity and mitigates drought [24], and it has the potential to increase the availability of plants nutrient, increases growth and biomass of drought-stressed plants [25].

Table 5. The analysis of financial farming system on the corn cultivation in dry land, Gunungkidul

	Description	Corn cultivation system by supplementary water irrigation					
		F1M MM	F1M3	F2M1	F2M3	F3M1	F3M3
		IDR/ 0.1 ha	IDR/ 0.1	IDR/ 0.1	IDR/ 0.1ha	IDR/ 0.1 ha	IDR/ 0.1 ha
A. Explicit Cost		1,090,000	1,690,000	1,090,000	1,690,000	1,090,000	1,690,000
I.	Production facilities	800,000	1,400,000	800,000	1,400,000	800,000	1,400,000
1	Seed (2.5 kg)	165.000	165.000	165.000	165.000	165.000	165.000
2	Fertilizer						
	Urea (15 kg)	175,000	175,000	175,000	175,000	175,000	175,000
	NPK 15:15:15 (20 kg)	240,000	240,000	240,000	240,000	240,000	240,000
	Organic fertilizer (300 kg/)	120,000	120,000	120,000	120,000	120,000	120,000
3	Pesticides	100,000	100,000	100,000	100,000	100,000	100,000
4	Ameliorant (400 kg)		600,000		600,000		600,000
II.	External work forces	240,000	240,000	240,000	240,000	240,000	240,000
III.	Other costs	50,000	50,000	50,000	50,000	50,000	50,000
B. Implicit Cost		600,000	600,000	600,000	600,000	600,000	600,000
IV.	Internal / family labour	600,000	600,000	600,000	600,000	600,000	600,000
C. Addition cost for irrigation		150,000	150,000	250 ,000	250,000	325,000	320,000
D. Total Cost (A+B+C)		1,840,000	2,440,000	1,940,000	2,540,000	2,015,000	2,615,000
E. Total income		3,478,500	4,041,500	4,263,000	5,430,000	4,480,000	4,789,000
a. Yield of corn		2,623,500	3,091,500	3,213,000	3,555,000	3,330,000	3,519,000
b. Biomass of corn yield		855,000	950,000	1,050,000	1,875,000	1,150,000	1,270,000
F. Income (E-A)		2,388,500	2,351,500	3,173,000	3,740,000	3,390,000	3,099,000
G. Benefid (E-D)		1,638,500	1,601,500	2,323,000	2,890,000	2,465,000	2,174,000
H. Farming system feasibility indicator							
1. B/C (Rasio Benefid vs Total cost), Feasible >1		0.92	0.73	1.19	2.25	1.23	2.18
2. R/C (Rasio Income vs Total cost), Feasible >2		1.93	1.74	2.21	3.26	2.25	3.19

4 Conclusion

The dry land on Wonosari, Gunungkidul which applied supplementary water irrigation two time a week plus rice straw as mulch and rice husk on dosage 4 ton/ha/season given the optimal package treatment and it was not significantly different to the three times a week watering irrigation and generated improvement growth and higher yield of corn than other treatments.

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Improving the quality of land by applying rice straw mulch and rice husk plus supplementary water irrigation two times a week was able to increase C-organic, P total content and soil CEC soil compared to the farmer's habit in dry land and provide the highest corn production (7.95 ton. ha^{-1}) and increased the corn yield 52.56% more higher than control

The analysis of financial farming system of F2M3 treatment (Giving irrigation 2 times a week + rice straw + rice husk 4 ton.ha^{-1}) is more higher (BC ratio = 2.25) than F3M3 treatment (Giving irrigation 3 times a week + rice straw + rice husk) which gave BC ratio only 2.18 due to additional water irrigation cost.

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