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Harvest Time and Yield of Traditional Rice Cultivars Based on N and P Fertilizer Management

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ABSTRACT

Objectives of this study were to improving yield and shortening the crop duration of traditional rice cultivar by manipulating fertilization of N and P, and to find the genetic resources for breeding program. Fertilizer application as main plot viz. N_1P_1 = (50 kg N and 30 kg P_2O_5)ha^{-1}, N_1P_2 = (50 kg N and 60 kg P_2O_5) ha^{-1}, N_2P_1 = (75 kg N and 30 kg P_2O_5) ha^{-1}, N_2P_2 = (75 kg N and 60 kg P_2O_5) ha^{-1}, N_3P_1 = (100 kg N and 30 kg P_2O_5) ha^{-1}, N_3P_2 = (100 kg N and 60 kg P_2O_5) ha^{-1} and sub plot of traditional cultivars viz. Ase Andale, Brandi, Dusel, Luwung, Mayangsari, Solo and Ciherang (check) were test under split plot design with three replicates. Combined N-P fertilizer gave no effect to harvest time and yield of traditional rice cultivars. Ase Andale, Brandi, Dusel and Luwung cultivars obtained higher biomass than other cultivars which referred to the higher number of grain per panicle, dry weight, and grain weight per plant. Mayangsari and Solo cultivars had shorter harvest time and Luwung had a highest yield compared to Ciherang as check. Those cultivars were potential as rice genetic sources to be developed.

Keywords: traditional cultivar, N-P fertilizer, harvesting time, yield

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INTRODUCTION

Rice (Oryza sativa) as a source of about 65% caloris and 38% protein of Indonesian dietary has been irreplaceable [1]. To meet people's demand, rice productivity and its quality such as taste, nutritional properties, and resistance against pests and diseases have been engineered. In general, rice breeding is aimed to improve yield and quality [2].

Traditional rice cultivars are replacement by new developed cultivars with the specific character and high yield since green revolution was exposed [3]. In China ex-situ conservation of traditional rice cultivars have significantly expanded for sustainable way [4]. Meanwhile, in Indonesia, although traditional rice has been not been expanded but it have an important role in national rice production [5].

Some farmers have been growing traditional rice cultivars even long duration and low in productivity. But farmers prefer grow short duration than long duration of rice cultivars because of easier and more efficient in crop management and field practice. They will save more energy, including water, fertilizer and labor, when they grow in short duration.

Therefore, cultivated traditional rice has dramatically been decreased and locally extinct. However, their special taste and, resistance against diseases and pests originally is a reason to implemented [6]. Therefore, plant breeders could be possible to develop their genes capacity. Although traditional rice cultivars have some advantages, there have some limitations such as long crop duration, high plant height, less tiller and low yield, generally. Improvement yield can be achieved by selecting among high potency of traditional cultivars and suitable grown in a given area [7]

Commonly, farmers prefer grow short duration than long duration of rice cultivars because of easier and more efficient in crop management and field practice. They will save more energy, including water, fertilizer and labor, when they grow in short duration. In tropic areas, rice growth period can be manipulated through crop management [8], such as fertilization [9]

Proper N application could be gained a good performance in growth and yield [10]. Nitrogen application at appropriate dose on some traditional rice of Badangbuyur, Reki, Basier, Si Rantau and Mayangsari cultivars improves yield [11]. Availabiltiy of P in soil and readily uptake by plant is low in tropical soil [12]. Meanwhile, phosphorous is an important plant nutrition to enhance capacity of N uptake by plant and vise versa [13]. Plant could not give positive response on N under P deficiency condition (Graham and Vance [14], Buresh et al. [15]). Availability of N in the environment where a given set of genotypes is evaluated plays a very important role in the expression of P [16]. Therefore, N-P is couple mutualism plant nutrition by which plant will have capacity to uptake and attain the high yield.

In tropic areas, rice growth period can be manipulated through crop management [8], such as fertilization [9]. Therefore, it is needed to explore response of N-P application on improve shortening crop duration and yield under full irrigation. Manipulation N-P fertilizer is expected to be able to promote early reproductive stage and could increase the yield. Furthermore, the manipulation is also to express genetic characteristics in various N and P status, by which new cultivars can be developed.

The objective of the study was to observe the effect of manipulation of N-P fertilizer on crop duration, plant growth, yield and genetic resources for further development of traditional rice cultivars. The result could hopefully contribute to an improvement in traditional rice management and provide useful information for the selection and breeding program.

MATERIALS AND METHODS

Field experiment was conducted at irrigated rice field in Bantarwuni Village, Kembaran, Banyumas, Indonesia in 2009. The topography of the study area is flat with an approximate slope of 0 – 5%. Split-plot design was applied with the main plot of fertilizer treatment viz. N_1P_1= (50 kg N and 30 kg P_2O_5)ha^{-1}, N_1P_2 = (50 kg N and 60 kg P_2O_5) ha^{-1}, N_2P_1 = (75 kg N and 30 kg P_2O_5) ha^{-1}, N_2P_2 = (75 kg N and 60 kg P_2O_5) ha^{-1}, N_3P_1 = (100 kg N and 30 kg P_2O_5) ha^{-1}, N_3P_2 = (100 kg N and 60 kg P_2O_5) ha^{-1} and traditional cultivars of Ase Andale, Brandi, Dusel, Luwung, Mayangsari, Solo and Ciherang (check) as sub plot with three replication. Ciherang is well known as earliness and high yield cultivar.

Fertilizer application treatments were randomly assigned to main plots (32 m x 4 m) and traditional cultivars to subplots (3 m x 3 m). Subplots were 1 m a part strips and main plots by a 1.5 m. Three rice seedlings were dibbled on the field on an intra-row spacing of 20 cm. Each plot received N-P as treatment and K at the rate of 10 kg ha^{-1} using urea (46% N), super triphosphate (19.8 % P_2O_5) and muriate of potash (50% K_2O), respectively as a basal dressing at fourteen days after sowing. The seedlings were thinned out to two plants per hill 14 days after emergence before fertilizer applied. The full amount of P and K, and one-half of N were applied at two weeks after transplanting. The remaining N was applied at 4 weeks after transplanting.

Parameters of crop development data such as plant height, weight of dry biomass, days to flowering, days to harvest, numbers of productive tiller, grain number per panicle, weight of 1000 grains, percentage of unfilled grain and grain weight were recorded by taking 10 samples per sub plot. Plant height was measured from the ground level up to the panicle of the flag leaf at the end of vegetative stage. Weight of dry matter at harvest was collected randomly selected rice plants from each treatment, and dry weight was recorded after oven-drying. Days to flowering and harvest estimated at 80 percent of both stages was reached.

Yield and yield components, i.e. numbers of productive tiller, grain number per panicle, weight of 1000 grains, percentage of unfilled grain and grain weight were estimated from the same sample at harvest. Productive tiller was counted regarding to panicle development. Grain yield and 1000 grains weight, and moisture content was estimated from ten samples to convert the grain weight at harvest to grain weight at zero percent moisture, and then adjusted to 14% grain moisture content. Percentage of unfilled grains was done by calculated weight of unfilled grains to total grains.

Data collected were subjected to analysis of variance in which significant differences existed; Dunnet and Duncan Multiple Range Tests at 0.05 were used to separate the means among cultivars and combination of N-P fertilizer, respectively.

RESULTS AND DISCUSSION

There had no significant interaction between cultivar and fertilizer on all parameters. The effect of cultivar, however, was significant for all parameters. Fertilizer affected only on weight of 1000 grains.

It was identified that among traditional cultivars, Mayangsari and Solo were short (<100 cm), having plant height of 89.83 and 76.28 cm, respectively, insignificant to control (78.20 cm). Other cultivars (Ase Andale, Brandi, Dusel and Luwung) were gained higher plant height than control (Table 1). Mayangsari and Solo showed the short days to flowering and to harvest as well at 79.8 and 83.2 days and, at 109.7 and 110.5 days after transplanting, respectively. These characters were not significant with control. Ase Andale, Brandi, Dusel and Luwung cultivars were later to flowering and to harvest as follow at 97.6, 96.6, 99.8 and 108.6 days and, at 126.4, 126.7, 126.7, and 131.8 days, respectively.

Grouping of rice growth period can be divided into two major groups based on ICRR classification (2009) as short duration (105-124 days), medium duration (125-140 days), and late duration (141-160). Mayangsari and Solo were short duration group and others were medium duration.

Growth duration had a similar effect on plant height that long growth duration was indicate by high plant height and vice versa (Table 1). So, it is important to select a short plant height cultivars that minimize yield lost due to lodging, for rice breeding program. Mayangsari and Solo can potentially be the gene sources. Moreover, short plant will be managed easily and it has been considered that short plant of rice is more efficient in nutrient use, shown by the low biomass [17].

Based on Dunnet test, there was no significantly different among traditional cultivars and control in the number of tillers, percentage of unfilled grain and weight of 1000 grains. In parameter grain per panicle, Mayangsari (120.43 grains) and Solo (102.41 grains) had no significant to control (103.19 grains), and other cultivars showed higher number of grain per panicle than control (Table 1).

Table 1: Growth and yield of traditional rice and improved cultivars

Cultivar	Plant height (cm)	Numb er of tiller	Flowerin g stage (days)	Harvest time (days)	Grain number per panicle	unfilled grain (%)	Dry weight of biomas s (g)	1000 grains weight (g)	Grain weight per plant (g)
Ase andale	157,03 a	11,04	97,6 a	126,4 a	195,36 a	42,87	50,25 a	26,17	22,78 b
Brandi	129,31 a	12,63	96,6 a	126,7 a	167,17 a	37,27	52,96 a	25,72	24,17 b
Dusel	151,44 a	10,16	99,8 a	126,7 a	153,46 a	36,67	45,90 b	26,06	19,32 bc
Luwung	122,66 a	13,98	108,6 a	131,8 a	196,30 a	28,58	58,12 a	24,48	32,19 a
Mayangsari	89,83 b	13,58	79,8 b	109,7 b	120,43 b	30,87	35,56 b	25,67	20,96 bc
Solo	76,28 b	11,51	83,2 b	110,5 b	102,41 b	39,51	27,27 b	27,25	14,32 c
Ciherang (check)	78,20 b	11,44	83,1 b	111,2 b	103,19 b	34,29	28,23 b	27,58	15,82 c

Values sharing not similar letters differ significantly at P<0.05, according to Dunnet test

The number of tillers was no effect between short and medium duration cultivars. It was found that Luwung had the highest in number of tillers, relatively. The short duration cultivars reached flowering and harvested stages earlier than long duration cultivars. Days to flowering and to harvest are controlled by genetics. The short days to flowering and to harvesting are important to achieve higher production because of possibility to grow rice four times in a year [18], even gain low dry matter [17]. However, the total production in a year will be higher than other cultivar of which grown two times in a year. Character of short duration cultivar is the one source to be developed [18].

The medium duration cultivars obtained higher grain number per panicle than short duration cultivars (Table 1). Since grain number per panicle is the most important yield component [19], this fact indicates that medium duration rice has a better yield potency [20] and can be another genetic source to develop. In this study revealed that percentage of unfilled grain is not determined by both cultivar and fertilizer. As reported by [8], unfilled grain determines by water availability at reproductive stage, when plant needs water in large amount. The same case was identified in weight of 1000 grains of which no difference to control.

Dry matter of Dusel (45.90 g), Mayangsari (35.56 g) and Solo (27.27 g) was no significantly different to control (28.23 g), however, the remaining cultivars were higher. Grain weight among cultivars showed that Luwung gain the highest grain weight of 32.19 g (Table 1).

It was revealed that Luwung obtained the highest yield compared to control and other cultivars. This result was supported by some characters of high number of tillers, less unfilled grain, high grain number, and high biomass. However, Luwung was harvested the last (Table 1). Therefore, Luwung would be developed as a gene source to improve production.

Different fertilizer treatment had a significantly affect only on weight of 1000 grains. The higher weight of 1000 grains (27.05 g) gained at dose of 100 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1} than others even it was not significantly different with doses of (100 kg N and 30 kg P_2O_5) ha^{-1} and (75 kg N and 60 kg P_2O_5) ha^{-1} of 26.76 g and 26.43 g, respectively (Table 2).

The weight of 1000 grains is generated by fertilizer. Increased amount of N up to 75 kg ha^{-1} did not affect weight of 1000 grains. Increasing amount of 46 kg N ha^{-1} to 69 kg N ha^{-1} did not increase yield of traditional rice cultivars [21]. In this study was revealed that increasing N application up to 100 kg ha^{-1} improved weight of 1000 grains, however, N increase without P increased, did not significantly alter the weight. Raising dose of P application 30 kg ha^{-1} to 60 kg ha^{-1} did not increase weight of 1000 grains as well (Table 2). The result indicated that weight of 1000 grains improved caused by increasing of N and P amount. For wet-cultured rice that enhancing N fertilization significantly increased on long, wide and area of leaf [22] and advance photosynthesis rate [23]. Moreover, Role of N in plant maturity may increase grain weight [24]. It is a fact that high weight of 1000 grains due to increasing of N absorption, then, development of leaf was improved and enhance photosynthesis rate.

Table 2: Growth and yield based on different fertilizer treatments

Parameters/ Fertilizers	Plant height (cm)	Number of tiller	Flowering stage (days)	Harvest time (days)	Grain number per panicle	unfilled grain (%)	Dry weight of biomass (g)	1000 grains weight (g)	Grain weight per hill (g)
N1P1	113,88	12,33	93,1	121,1	137,76 b	37,57 a	41,01	25,57 c	19,422
N1P2	116,17	12,12	92,7	120,7	146,58 ab	36,33 abc	40,82	25,25 c	21,066
N2P1	110,27	11,11	93,3	120,0	151,60 ab	35,55 abc	38,46	25,74 bc	20,545
N2P2	115,93	12,46	93,5	121,7	142,15 ab	37,42 ab	42,08	26,43 abc	21,188
N3P1	116,63	11,71	91,8	119,6	152,77 ab	33,60 c	49,69	26,76 ab	22,485
N3P2	116,90	12,57	91,6	119,4	159,13 a	33,89 bc	43,62	27,05 a	23,488

Values sharing not similar letters differ significantly at $P<0.05$, according to DMRT.
N_1P_1 = (50 kg N and 30 kg P_2O_5)ha^{-1}; N_1P_2 = (50 kg N and 60 kg P_2O_5) ha^{-1};
N_2P_1 = (75 kg N and 30 kg P_2O_5) ha^{-1}; N_2P_2 = (75 kg N and 60 kg P_2O_5) ha^{-1};
N_3P_1 = (100 kg N and 30 kg P_2O_5) ha^{-1}, N_3P_2 = (100 kg N and 60 kg P_2O_5) ha^{-1}.

Thus, Increased P supply was followed by increased of weight of 1000 grains under optimum N status. The absorbed P is distributed over living cells especially in reproductive organ such as flower and seed [12]. As mentioned by [23], larger amount of P is accumulated in fruit and seed particularly in cereal plants i.e. rice.

CONCLUSIONS

Improved cultivars of Ciherang as a check with the characters of earliness and high yield compared to.Mayangsari and Solo cultivars had similar type of earliness even low in yield. Yet, Luwung obtained the highest yield with late duration to harvest. Manipulated N-P fertilizers could not be able yet to promote shorten growth duration to harvest and also yield of traditional rice cultivars. Therefore, improving of shortening growth period and yield would be reach by selecting the appropriate cultivars of which Mayangsari and Solo had capacity in short growth duration and Luwung had a high yield. Mayangsari, Solo and Luwung cultivars can be used as parental for plant breeding program to gain the character of short duration and high yield.

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