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Optimization of NPK and silica fertilizations for seed production of IPB 3S rice varieties in Pinrang, South Sulawesi

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Key words: Application frequency, Cultivation techniques, Fertilizer combination, Seed production

Abstract

The research aim to determinee the proper NPK dose and application frequency of silica fertilizer to seed production of IPB 3S rice. The research was carried on June – September 2017 in Pinrang, South Sulawesi. A Randomyzed Completely Block Design with nine levels (75% dose + once silica application, 75% dose + twice silica application, 75% dose + thrice silica application, 100% dose + once silica application, 100% dose + twice silica application)/ (300kg NPK ha^{-1}+ 150kg Urea ha^{-1} + twice silica application), 100% dose + thrice silica application, 125% dose + once silica application, 125% dose + twice silica application, and 125% dose + thrice silica application. 100% dose of fertilization is 300kg NPK ha^{-1} + 150kg Urea ha^{-1}. The combinations showed significant effect to flag leaves length, filled grain panicle^{-1}, filled grain percentage, grain weight plant^{-1}, and grain yield ha^{-1}. The combination of 300kg NPK ha^{-1} + 150kg Urea ha^{-1} + twice silica application obtained the highest filled grain panicle^{-1}, filled grain percentage, grain weight plant$^{-1,}$ and grain yield ha^{-1} than others. The combination of 300kg NPK ha^{-1} + 150kg Urea ha^{-1} + twice silica application was the best fertilization on seed production of IPB 3S rice in Pinrang, South Sulawesi.

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Introduction

IPB 3S rice varieties is an inbred rice which has high yield potential until 11.2 ton ha^{-1}. The high yield makes this varieties is important to be disseminated. Current, this varieties has been planted in many areas in Java Island, and began to be planted in Sumatera, Sulawesi, and Kalimantan Island.

The appropriate cultivation techniques are needed to disseminate of IPB 3S rice at outside Java Island. The cultivation techniques applied in Java Island by using NPK, Urea, and Silica fertilization. The dose of NPK and Urea used respectively i.e. 300kg ha^{-1} and 150kg ha^{-1} which was given three times during growth season (Department of Agronomy and Horticulture – Bogor Agricultural Univeristy, 2017). The first fertilization applied at 5-7 days after planting i.e. 100kg NPK ha^{-1} and 100kg Urea ha^{-1}. The second fertilization applied at 21 days after planting i.e 100 kg ha^{-1} and 50kg Urea ha^{-1}. The third fertilization applied at 35 days after planting i.e. 100kg NPK ha^{-1}.

NPK plays an important role to rice growth where N could increase plant height, tiller number, leaf size, and grain number $panicle^{-1}$ (Widiyawati *et al.* 2014), and it's important to photosynthesis rate and plant biomass (Doberman and Fairhust, 2000). The deficiency of N would reduce plant height, tiller number, leaf size, and grain number $panicle^{-1}$ (Chen *et al.*, 2014). The dose of N is too high would reduce filled grain of rice (Pirngadi *et al.*, 2007) so that N fertilizer must be given in the proper dose.

The other nutrient required by rice for optimum yield was Silica (Si). Si plays an important role to enhance rice growth (Pati *et al.,* 2016). The deficiency of Si increased leaf and stem evaporation to lead the drying plants, reduced the quality of seed (Makarim *et al.*, 2014), and reduced tiller number (Timotiwu and Dewi, 2014). The adding of Si was required to enhance the rice yield. Currently, Si was applied in many areas i.e. 1 litre ha^{-1} that was applied at 14 and 30 days after planting (Department of Agriculture and Horticulture - Bogor Agricultural University, 2017).

The dissemination efforts of IPB 3S rice are done by seed production in many other areas. Pinrang is a one of area which becomes centre of rice production in South Sulawesi. The develop of IPB 3S rice in outside Java island requires the study of proper cultivation techniques. The assesment of NPK, Urea and silica recommendation dose for seed production of IPB 3S rice in Pinrang is important to be done. The information of proper cultivation techniques for seed production of IPB 3S rice in Pinrang, South Sulawesi was not yet available. The research was conducted to determine the proper cultivation techniques (especially NPK, Urea, and silica dose) for seed production of IPB 3S rice in Pinrang, South Sulawesi.

Materials and methods

Place and time of research, and experiment design

The research was carried on June to September 2017 in Siparappe, Pinrang, South Sulawesi. A Randomyzed Completely Block Design with nine levels i.e. 75% dose + once silica application ($P_{75}S_1$), 75% dose + twice silica application ($P_{75}S_2$), 75% dose + thrice silica application ($P_{75}S_3$), 100% dose + once silica application ($P_{100}S_1$), 100% dose + twice silica application ($P_{100}S_2$), 100% dose + thrice silica application ($P_{100}S_3$), 125% dose + once silica application ($P_{125}S_1$), 125% dose + twice silica application ($P_{125}S_2$), and 125% dose + thrice silica application ($P_{125}S_3$), and each level was consisted of three replications. P_{100} refers to the use of 100% recommended fertilizer dose (300 kg NPK and 150 kg Urea), while P_{75} means 75% and P_{125} means 125% of recommended dose.

Planting

Rice seed of IPB 3S collected from Department of Agronomy and Horticulture, Faculty of Agriculture, Bogor Agricultural University. The soils were given 300kg ha^{-1} organic fertilizer at 1-3 days before planting. 14 days old seedlings after sowing was planted in plot (9m x 1.5m) using spacing 26cm x 27cm, and each hole was planted 4 seedlings. The combination fertilizer treatment of NPK and Urea was given at 1, 3, and 5 weeks after planting (WAP), gradually. Si silica fertilizer was applied at 2 WAP, S_2 was applied at 2 and 4 WAP, and S_3 was applied at 2, 4, and 6 WAP.

Observation and data analysis

The parameters observed were plant height, flag leaf length, tiller number, productive tiller number, panicle length, grain number panicle^{-1}, filled grain panicle^{-1} grain weight plant^{-1}, fresh weight of plant (stem and leaf), and seed moisture content at harvest time. The collected data were analyzed using analysis of variance (Anova) $\alpha = 0.05$, and will be continued duncan's test if showed significant effect by Statistical Tools Agricultural Research (STAR).

Results and discussion

Agronomic characters

Fertilizer combination showed significant effect to length of flag leaves and no significant to plant height (Table 1). The high dose of N fertilizer according to Tayefe *et al.* (2014) would increase plant height, however did not occur in this research. This was occured because the low dose of NPK (225kg ha^{-1}) + Urea 112.5kg ha^{-1} has been sufficient for rice growth, especially plant height.

Table 1. Effect of fertilizer combination to agronomyc characters of IPB 3S rice.

Fertilizer combination	Plant Height(cm)	Length of Flag Leaves (cm)
$P_{75}S_1$ (225 kg NPK ha^{-1} + 112.5 kg Urea ha^{-1} + once Si application)	82.6	41.6 bc
$P_{75}S_2$ (225 kg NPK ha^{-1} + 112.5 kg Urea ha^{-1} + twice Si application)	80.0	39.4 c
$P_{75}S_3$ (225 kg NPK ha^{-1} + 112.5 kg Urea ha^{-1} + thrice Si application)	80.6	37.6 c
$P_{100}S_1$ (300 kg NPK ha^{-1} + 150 kg Urea ha^{-1} + once Si application)	79.8	41.2 bc
$P_{100}S_2$ (300 kg NPK ha^{-1} + 150 kg Urea ha^{-1} + twice Si application)	80.4	39.6 c
$P_{100}S_3$ (300 kg NPK ha^{-1} + 150 kg Urea ha^{-1} + thrice Si application)	79.2	41.6 bc
$P_{125}S_1$ (375 kg NPK ha^{-1} + 187 kg Urea ha^{-1} + once Si application)	80.6	54.4 a
$P_{125}S_2$ (375 kg NPK ha^{-1} + 187 kg Urea ha^{-1} + twice Si application)	80.2	47.0 abc
$P_{125}S_3$ (375 kg NPK ha^{-1} + 187 kg Urea ha^{-1} + thrice Si application)	79.6	51.8 ab

Means within each coloumn followed by the same letter do not differ significantly at the $P < 0.05$ level using Duncan's test.

Flag leaves were the highest leaf and has different size to others leaf. Small flag leaves showed less competitive in accumulation of assimilate, especially at grain filling phase (Makarim and Suhartatik, 2009). The higher dose of NPK fertilizer would increase length of flag leaves (Table 1). The fertilizer dose of 375 kg NPK ha^{-1} + 187 kg Urea ha^{-1} resulted the highest length of flag leaves than other doses.

Yield components

Fertilizer dose showed no significant effect to number of tiller and number of productive tiller (Table 2). The NPK dose of 300kg ha^{-1} showed more high number of tiller and number of productive tiller than others combination. Panicle length was important character in rice growth which will determine the number of grain resulted. Panicle length according to Zahra *et al.* (2011) was very affected by N fertilizer. Fertilizer combination showed no significant effect to panicle length of IPB 3S rice planted in Pinrang (Table 2).

The longer panicle was obtained on dose 300kg NPK ha^{-1} + 150kg Urea ha^{-1} and twice silica application, i.e. 29.3 cm and the shortest panicle was obtained on dose 375kg NPK ha^{-1} + 187kg Urea ha^{-1} and twice silica application.

Table 2. Effect of fertilzer combination to number of tiller, number of productive tiller, and panicle length IPB 3S rice.

Fertilizer combination	NT (tiller)	NPT (tiller)	PL (cm)
$P_{75}S_1$ (225 kg NPK ha^{-1} + 112.5 kg Urea ha^{-1} + once Si application)	21	19	28.2
$P_{75}S_2$ (225 kg NPK ha^{-1} + 112.5 kg Urea ha^{-1} + twice Si application)	20	19	28.7
$P_{75}S_3$ (225 kg NPK ha^{-1} + 112.5 kg Urea ha^{-1} + thrice Si application)	17	17	28.6
$P_{100}S_1$ (300 kg NPK ha^{-1} + 150 kg Urea ha^{-1} + once Si application)	23	22	28.3
$P_{100}S_2$ (300 kg NPK ha^{-1} + 150 kg Urea ha^{-1} + twice Si application)	21	21	29.3
$P_{100}S_3$ (300 kg NPK ha^{-1} + 150 kg Urea ha^{-1} + thrice Si application)	24	24	28.8
$P_{125}S_1$ (375 kg NPK ha^{-1} + 187 kg Urea ha^{-1} + once Si application)	18	17	28.5
$P_{125}S_2$ (375 kg NPK ha^{-1} + 187 kg Urea ha^{-1} + twice Si application)	23	21	27.6
$P_{125}S_3$ (375 kg NPK ha^{-1} + 187 kg Urea ha^{-1} + thrice Si application)	19	18	28.4

NT=Number of Tiller, NPT=Number of Productive Tiller, PL=Panicle Length.

Grain number very relate to panicle length (Fatimaturrohmah *et al.*, 2016). Generally, the long panicles will be resulted the high seed number. Fertilizer combination showed significant effect to number of filled seed per panicle and percentage of filled seed, however no significant to seed number per panicle (Table 3). Fertilizer combination of $P_{100}S_2$ (300kg NPK ha^{-1} and 150kg Urea ha^{-1} + twice silica application) resulted the highest number of filled seed per panicle and percentage of filled seed.

This combination significant different to other combination based on number of filled seed per panicle, and didn't significant different to $P_{100}S_1$ (300kg NPK ha^{-1} + 150kg Urea ha^{-1} + once silica application), $P_{100}S_3$ (300kg NPK ha^{-1} + 150kg Urea ha^{-1} + thrice silica application), and $P_{125}S_2$ (375kg NPK ha^{-1} + 187kg Urea ha^{-1} + twice silica application) based on percentage of filled seed. This showed that the low dose of NPK fertilizer would decreased of grain filling and forming, and the high dose of NPK fertilizer would also decreased number of filled seed and increased number of empty seed. The high dose of N in accord with Kusuma (2015) could decrease of number of filled seed and increased number of empty seed.

Tabel 3. Effect of fertilizer combination to number of seed per panicle, number of filled seed per panicle, and percentage of filled seed IPB 3S rice.

Fertilizer combination	NS/P (seed)	NFS/P (seed)	% FS
$P_{75}S_1$ (225 kg NPK ha^{-1} + 112.5 kg Urea ha^{-1} + once Si application)	171.6	115.2 b	67.3 b
$P_{75}S_2$ (225 kg NPK ha^{-1} + 112.5 kg Urea ha^{-1} + twice Si application)	182.4	127.8 b	69.7 b
$P_{75}S_3$ (225 kg NPK ha^{-1} + 112.5 kg Urea ha^{-1} + thrice Si application)	182.0	121.0 b	67.9 b
$P_{100}S_1$ (300 kg NPK ha^{-1} + 150 kg Urea ha^{-1} + once Si application)	174.2	131.4 b	75.2 ab
$P_{100}S_2$ (300 kg NPK ha^{-1} + 150 kg Urea ha^{-1} + twice Si application)	211.8	173.8 a	82.6 a
$P_{100}S_3$ (300 kg NPK ha^{-1} + 150 kg Urea ha^{-1} + thrice Si application)	176.8	134.4 b	76.1 ab
$P_{125}S_1$ (375 kg NPK ha^{-1} + 187 kg Urea ha^{-1} + once Si application)	170.0	122.0 b	72.1 b
$P_{125}S_2$ (375 kg NPK ha^{-1} + 187 kg Urea ha^{-1} + twice Si application)	168.6	125.0 b	74.2 ab
$P_{125}S_3$ (375 kg NPK ha^{-1} + 187 kg Urea ha^{-1} + thrice Si application)	177.0	127.2 b	71.7 b

Means within each coloumn followed by the same letter do not differ significantly at the $P < 0.05$ level using Duncan's test. NS/P=Number of Seed Per Panicle, NFS/P=Number of Filled Seed Per Panicle, % FS= Percentage of Filled Seed.

Fertilizer combination of $P_{100}S_2$ (300kg NPK ha^{-1} + 150kg Urea ha^{-1} + twice silica application) resulted the highest seed weight per plant and significant different to other combination, except $P_{100}S_1$ (300kg NPK ha^{-1}+ 150kg Urea ha^{-1} + once silica application), $P_{100}S_3$ (300kg NPK ha^{-1} + 150kg Urea ha^{-1} + thrice silica application), and $P_{125}S_2$ (375kg NPK ha^{-1}+ 187kg Urea ha^{-1} + twice silica application) (Table 4). The fresh weight of plant could be used to estimate yield, because the high fresh weight of plant will increase the yield. This research showed fertilizer combination didn't affect to fresh weight of plant.

Table 4. Effect of fertilizer combination to plant of fresh weight and seed weight per plant IPB 3S rice

Fertilizer combination	PFW (g)	SW/P (g)[a]
$P_{75}S_1$(225 kg NPK ha^{-1} + 112.5 kg Urea ha^{-1} + once Si application)	156.1	66.1 b
$P_{75}S_2$(225 kg NPK ha^{-1} + 112.5 kg Urea ha^{-1} + twice Si application)	136.0	67.5 b
$P_{75}S_3$(225 kg NPK ha^{-1} + 112.5 kg Urea ha^{-1} + thrice Si application)	137.0	68.0 b
$P_{100}S_1$(300 kg NPK ha^{-1} + 150 kg Urea ha^{-1} + once Si application)	178.0	81.0 a
$P_{100}S_2$(300 kg NPK ha^{-1} + 150 kg Urea ha^{-1} + twice Si application)	170.0	84.8 a
$P_{100}S_3$(300 kg NPK ha^{-1} + 150 kg Urea ha^{-1} + thrice Si application)	188.0	80.8 a
$P_{125}S_1$(375 kg NPK ha^{-1} + 187 kg Urea ha^{-1} + once Si application)	144.0	68.1 b
$P_{125}S_2$(375 kg NPK ha^{-1} + 187 kg Urea ha^{-1} + twice Si application)	160.0	59.9 b
$P_{125}S_3$(375 kg NPK ha^{-1} + 187 kg Urea ha^{-1} + thrice Si application)	148.0	70.1 b

Means within each coloumn followed by the same letter do not differ significantly at the $P < 0.05$ level using Duncan's test. PFW=Plant of Fresh Weight, SW/P=Seed Weight Per Panicle.

Production

Rice production was affected by many characters, among others number of tiller, number of productive tiller, panicle length, number of seed per panicle, number of filled grain per panicle, and seed weight per plant. NPK fertilization of dose 300kg ha^{-1} showed the highest grain yield than dose 225kg ha^{-1} and 375kg ha^{-1} (Table 5).

Table 5. Effect of fertilizer combination to IPB 3S rice yield.

Fertilizer combination	Yield (ton ha^{-1})[a]	SMC (%)
$P_{75}S_1$(225 kg NPK ha^{-1} + 112.5 kg Urea ha^{-1} + once Si application)	9.1 b	20.2
$P_{75}S_2$(225 kg NPK ha^{-1} + 112.5 kg Urea ha^{-1} + twice Si application)	9.3 b	21.7
$P_{75}S_3$(225 kg NPK ha^{-1} + 112.5 kg Urea ha^{-1} + thrice Si application)	9.3 b	22.4
$P_{100}S_1$(300 kg NPK ha^{-1} + 150 kg Urea ha^{-1} + once Si application)	11.1 a	22.0
$P_{100}S_2$(300 kg NPK ha^{-1} + 150 kg Urea ha^{-1} + twice Si application)	11.6 a	21.7
$P_{100}S_3$(300 kg NPK ha^{-1} + 150 kg Urea ha^{-1} + thrice Si application)	11.1 a	22.3
$P_{125}S_1$(375 kg NPK ha^{-1} + 187 kg Urea ha^{-1} + once Si application)	9.3 b	22.6
$P_{125}S_2$(375 kg NPK ha^{-1} + 187 kg Urea ha^{-1} + twice Si application)	8.2 b	23.1
$P_{125}S_3$(375 kg NPK ha^{-1} + 187 kg Urea ha^{-1} + thrice Si application)	9.6 b	24.0

Means within each coloumn followed by the same letter do not differ significantly at the $P < 0.05$ level using Duncan's test. SMC=Seed Moisture Content.

The frequency of silica application was not different among once, twice, and thrice application at all of NPK dose. This showed that the low and high dose of NPK fertilizer will decrease rice yield (Heve *et al.,* 2017; Kamal *et al.,* 2016). The information of seed moisture content at harvest is important to determine the right harvest time. Rice seed moisture content at harvested was 20% - 24% (Table 5). This showed the harvest was done at the right time, where according to Suciaty (2007) seed moisture content about 21% - 26% was the right time to harvest.

Conclusion

Fertilizer combination has significant effect to length of flag leaves, number of filled seed per panicle, percentage of filled seed, seed weight per plant, and grain yield per hectare. Fertilier combination of $P_{100}S_2$ (300kg NPK ha^{-1} + 150kg Urea ha^{-1} + twice silica application) resulted the highest number of filled seed per panicle, percentage of filled seed, seed weight per plant, and yiled per hectare. This combination was the best fertilization for seed productio of IPB 3S rice in Pinrang, South Sulawesi.

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