Asian Journal of Plant Sciences

ISSN 1682-3974

OPEN ACCESS Asian Journal of Plant Sciences

ISSN 1682-3974
DOI: 10.3923/ajps.2024.193.204

Research Article
Effect of Planting Dates, Potassium Fertilizer Resources and Varieties on Growth, Yield and Proline of Rice Plants Under Rainfed Lowlands

[1,2]Novia Chairuman, [3]Rosmayati, [3]Hamidah Hanum and [4]Ali Jamil

[1]Doctoral Program of Agricultural Sciences, Faculty of Agriculture, Universitas Sumatera Utara, Padang Bulan, Medan 20155, Indonesia
[2]Research Center of Food Crops, Organization for Agriculture and Food, National Research and Innovation Agency, West Java 16911, Indonesia
[3]Program Study of Agrotechnology, Faculty of Agriculture, Universitas Sumatera Utara, Padang Bulan, Medan 20155, Indonesia
[4]Directorate General of Agricultural Infrastructure and Facilities, Ministry of Agriculture, Ragunan, South Jakarta 12550, Indonesia

Abstract
Background and Objective: Drought stress under rainfed lowlands had an inhibition the rice growth and yield. This study aimed to determine the effect of planting dates, fertilization, varieties and their interactions on the growth, yield and proline content of rice under rainfed lowlands. **Materials and Methods:** This study was conducted in the Deli Serdang District, North Sumatra, Indonesia from January to April, 2016. A split-split plot design was selected in this study with three replications. Main plot was planting dates (P1 = 10th, P2 = 20th and P3 = 30th January), sub-plot was potassium fertilizer resources (F0 = control, F1 = 50 kg ha^{-1} KCl, F2 = 5 ton ha^{-1} rice straw compost/RSC, F3 = 2.5 ton ha^{-1} RSC+2.5 ton ha^{-1} cattle manure/CM, F4 = 50 kg ha^{-1} KCl+5 ton ha^{-1} RSC, F5 = 50 kg ha^{-1} KCl+2.5 ton ha^{-1} and RSC+2.5 ton ha^{-1} CM) and sub-sub plot was rice varieties (V1 = Situ Bagendit, V2 = Towuti, V3 = Batutegi, V4 = Inpago-8, V5 = Inpago-9, V6 = Inpago-10, V7 = Ciherang and V8 = Inpari-10). The F and Duncan's tests were selected for data analysis. **Results:** The P1, F3-F5, Inpago-9 variety and their interactions (P1F4, P1F5, P1V2, P1V3, P1V5, P1V8, F5V5 and F5V1) significantly increased highest of rice growth and yield under rainfed lowlands. The P1F4V2, P1F4V3, P1F4V4 and P1F5V5 interactions could increase the number of filled grains of rice under rainfed lowlands. The proline content was negatively correlated to the grain yield of all varieties due to the three interactions. **Conclusion:** The early planting with a combination of KCl+RSC+CM on the Towuti, Batutegi, Inpago-8 and Inpago-9 varieties can be implemented as an alternative in rainfed lowlands.

Key words: Planting date, potassium fertilizer, rainfed fields, rice varieties, yield

Citation: Chairuman, N., Rosmayati, H. Hanum and A. Jamil, 2024. Effect of planting dates, potassium fertilizer resources and varieties on growth, yield and proline of rice plants under rainfed lowlands. Asian J. Plant Sci., 23: 193-204.

Corresponding Author: Novia Chairuman, Doctoral Program of Agricultural Sciences, Faculty of Agriculture, Universitas Sumatera Utara, Padang Bulan, Medan 20155, Indonesia
Research Center of Food Crops, Organization for Agriculture and Food, National Research and Innovation Agency, West Java 16911, Indonesia

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Rice yield in Indonesia were dominantly from irrigated fields by 55.41% and rainfed lowlands at 44.59% with an area covering 3.3 million ha[1]. It has been reported that the yield of rainfed lowlands were lower compared to irrigated fields[2]. Aleminew *et al.*[3] found that three rice varieties tested including Hiber, Ediget and X-jigna under rainfed lowland had a yield of 3.8, 3.5 and 3.1 ton ha^{-1}, respectively. Jonharnas and Sitindaon[4] reported that rice productivity of rainfed lowlands in the dry and rainy seasons were 3.20 and 4.50 ton ha^{-1}, respectively. Rice growing in rainfed lowlands has several problems because the main source of irrigation from rainfall[5] and during the dry season the rice plants are under drought stress[6]. During the rainy season, rice plants are under flooding stress, phosphorus deficiency and iron toxicity[7]. In addition, another problems in rainfed lowland rice is lower soil fertility. Jawang[8] reported that the soil pH and available-P in rainfed lowland rice in East Nusa Tenggara were acidic and low. Benauli[9] added that the low nutrient of N and K_2O in rainfed lowland rice. Low soil fertility in rainfed lowlands can be caused by the nutrient deficiency and Boling *et al.*[10] reported that insufficient N and K nutrients inhibit the yield of rainfed lowland rice. In addition, drought stress on rainfed lowland rice had an inhibition in the growth and yield of rice plants, but the antioxidants, polyphenols and prolines contents have been increased[11,12].

The problem of rainfed lowland rice needs to be improved through several efforts, such as the use of tolerant varieties through early selection[13], water management, application of organic matter[14], planting dates[15], combination of organic and inorganic fertilizers, especially the increase of potassium nutrient[16] and other efforts. The technique of planting date (early) has been reported to improve the agronomic, physiological and yield characteristics of rice compared to delay planting[15,17]. Rahim *et al.*[18] reported that several high-yielding varieties have been released and are adaptive to rainfed lowlands, such as Ciherang and Inpari 32. Jauhari *et al.*[19] found new high-yielding varieties of rice plants such as Inpago-5, Inpago-8, Inpago-9 and Inpari-19 were able to produce satisfactorily under rainfed lowlands.

In addition, the application of organic matter from plant residues and manure can support the yield optimization under rainfed lowlands. Ogbodo[20] and Rahman *et al.*[21] reported that the application of organic matter from plant residues and rice straw significantly increased soil pH, total-N, available-P and exchangeable-K. Sudarsono *et al.*[22] also found the use of cattle manure at 10 ton ha^{-1} significantly increased the uptake of total-N, total-P and increase the plant height, number of tillers, relative growth rate, leaf area and grain weight. Andrias *et al.*[23] also added that the combination of NPK fertilizer with organophosphates and rice straw significantly increased the number of panicles/clumps and filled grain/panicles in rice plant under rainfed lowlands.

Based on the previous studies, it is necessary to develop tests of several rice varieties such as Situ Bagendit, Towuti, Batutegi, Inpago-8, Inpago-9, Inpago-10, Ciherang and Inpari-10 with a potential yield from 6.0 to 8.5 ton ha^{-1} based on the Indonesian Center for Rice Research. Several tests can be conducted for optimizing rice yield under rainfed lowlands in this study focused on the planting dates, KCl+rice straw, compost+cattle manure and the use of several upland and lowland rice varieties. This study aimed to obtain the effect of planting dates (P), fertilization (F), varieties (V) and their interactions (PF, PV, FV, PFV) on growth and yield and their relationship to proline contents in rice plants under rainfed lowlands.

MATERIALS AND METHODS

Study area: This study was conducted at Serdang Village, Beringin Subdistrict, Deli Serdang District, North Sumatra, Indonesia (3°38'32"N and 98°49'43"E) from January to April, 2016. The study area was classified as rainfed lowland rice and located at an altitude of ±5 m.a.s.l. with an average rainfall was 1900 mm $year^{-1}$ and temperature ranging from 26 to 28°C.

Selection materials (varieties and organic matter): The rice varieties in this study were collected from the Indonesian Center for Rice Research, Sukamandi, Subang, West Java, Indonesia (Table 1). The upland rice varieties (Situ Bagendit, Towuti, Batutegi, Inpago-8, Inpago-9, Inpago-10) and the lowland rice (Ciherang, Inpari-10) were selected in this study. The rice straw compost (RSC) and cattle manure (CM) were selected and analyzed. The RSC had an organic-C, total-N, total-P_2O_5, total K_2O, water content and C/N ratio were 8.39, 1.06, 1.11, 1.36, 63.78% and 7.92, respectively. Likewise, the CM were 9.21, 0.95, 0.64, 3.90, 35.00% and 9.69, respectively.

Land preparation and study design: Soil samples were taken randomly at a depth of 0-20 cm, then composited and analyzed for initial soil characteristics (Table 2). The treatment plots were made with a size of 4×5 m, the distance between plots was 30 cm and the distance between replicates was 50 cm. The plots were formed using a split-split-plot design with 3 replications. Main plot (planting dates): P1 = 10,

Table 1: Description of the yielding characteristics of upland and lowland rice varieties

	Yielding characteristics		
Varieties	Thousand-grain weight (g)	Yield average (ton ha^{-1})	Yield potential (ton ha^{-1})
Upland rice			
Situ Bagendit	27.5	4.0	6.0
Towuti	26.0	4.0	7.0
Batutegi	25.0	3.0	6.0
Inpago-8	-	5.2	8.1
Inpago-9	-	5.2	8.4
Inpago-10	-	4.0	7.3
Lowland rice			
Ciherang	28.0	6.0	8.5
Inpari-10	-	5.0	7.0

Source: Indonesian Center for Rice Research

Table 2: Initial soil characteristics in this study

Soil characteristics	Methods	Value	Criteria*
pH (H_2O)	Electrometry	5.70	Moderately acid
Organic-C (%)	Spectrophotometry	1.12	Low
Total-N (%)	Kjeldahl	0.10	Low
Total- P_2O_5 (mg/100 g)	Spectrophotometry	48.32	High
Available-P (ppm)	Bray-I	19.26	Moderate
Exchange-K (me/100 g)	Atomic Absorption Spectrometry (AAS)	0.26	Low
Total-K_2O (mg/100 g)	AAS	45.33	High
Na (me/100 g)	AAS	0.36	Moderate
Ca (me/100 g)	AAS	9.98	High
Mg (me/100 g)	AAS	3.81	High
Zn (ppm)	AAS	6.8	Very low
CEC (me/100 g)	AAS	26.85	High
Texture	Hydrometer		
Sand (%)		25.51	Loam
Silt (%)		49.87	
Clay (%)		24.62	

*Classification of soil characteristics refers to SRI[24]

P2 = 20 and P3 = 30th of January. Sub-plots (fertilization): F0 = control, F1 = 50 kg ha^{-1} KCl, F2 = 5 ton ha^{-1} rice straw compost/RSC, F3 = 2.5 ton ha^{-1} RSC+2.5 ton ha^{-1} cattle manure/CM, F4 = 50 kg ha^{-1} KCl+5 ton ha^{-1} RSC and F5 = 50 kg ha^{-1} KCl+2.5 ton ha^{-1} RSC+2.5 ton ha^{-1} CM. The sub-sub-plots (rice varieties): V1 = Situ Bagendit, V2 = Towuti, V3 = Batutegi, V4 = Inpago-8, V5 = Inpago-9, V6 = Inpago-10, V7 = Ciherang and V8 = Inpari-10.

Cultural practices: The RSC and CM were applied a week before planting based on the treatment and mixed evenly to a depth of 20 cm. Doses of 2.5 and 5 ton ha^{-1} of RSC were converted to 5 and 10 kg per plot and 2.5 ton ha^{-1} of CM were converted to 5 kg per plot. Seedlings are conducted by soaking the seeds in the water for 24 hrs and then incubation for 48 hrs. Seeds are sown marked and have germinated. Planting was conducted at the age of 10 days after sowing with three seedlings per hole and used the planting system was 2:1 legowo. Basic fertilization was conducted 7 days after planting (DAP) with 250 kg ha^{-1} urea and 75 kg ha^{-1} SP-36, meanwhile, KCl based on treatment was given 2 times (7 and 40 DAP). Weed control was conducted according to field conditions manually, meanwhile, pest and disease control were conducted by spraying insecticide and fungicide. Harvesting was conducted after the rice grain had turned 95%.

Parameters and data analysis: The parameters of this study included plant height (PH), number of productive tillers (NPT), total chlorophyll (TC), panicle length (PL), number of filled grain (NFG), thousand-grain weight (TGW), grain yield (GY) and proline content (PC). The NPT was counted when the rice plant produced grains. The TC measurements were conducted on the base, middle and apex of leaves using a SPAD 502 plus chlorophyll meter. Homogeneous grain size of 1,000 was selected and then weighed. The calculation of GY was conducted by converting to the formula Eq. 1. The PC was analyzed from leaf samples at the age of 60 DAP based on the method of Bates *et al.*[25] using the Beckman DB-G Spectrophotometer. The proline concentration was determined from the standard curve and calculated using Eq. 2. The data were analyzed using the F-test and continued by the DMRT at $p<0.05$. The data were natural logarithmic and Pearson correlation analysis was performed using IBM SPSS v.20 software:

$$\text{Grain yield (ton ha}^{-1}) = \frac{10{,}000\ \text{m}^2}{\text{Plot area}} \times \text{grain yield/plot} \quad (1)$$

$$\text{Proline content}\left(\mu\text{mol g}^{-1}\right) = \frac{(\mu\text{g prolin/mL} \times \text{mL toluene})/115.5\ \mu\text{g}/\mu\text{mol}}{\text{Fresh weight (g)}} \quad (2)$$

RESULTS AND DISCUSSION

Based on the analysis of variance, the planting dates (P), fertilization (F) and varieties (V) significantly increased the growth, yield and proline content of rice plants under rainfed lowland (Table 3). The interaction of planting dates with fertilization (P×F) significantly increased the number of filled grain, grain yield and proline content of rice plants under rainfed lowland. Likewise, the interaction of planting dates with varieties (P×V) significantly increased the plant height, number of productive tillers, total chlorophyll, panicle length, the number of filled grain and grain yield. In addition, the interaction of fertilization with varieties (F×V) significantly increased the number of filled grain, thousand grain weight and proline content. However, the P×F×V interactions only significantly increased the number of filled grain.

Effect of planting dates, fertilization and varieties: The early planting (10th January/P1) showed a higher plant height, number of productive tillers, total chlorophyll, panicle length, number of filled grains, thousand-grain weight and grain yield (Table 4), but it had a lower proline content compared to other planting dates (P2 and P3). It was due to the earlier planting of rice plants leading to a higher accumulation of biomass than the delayed planting. These results were supported by Satapathy *et al.*[15], Mukesh *et al.*[17] and Khalifa[26] that early planting of rice resulted in physiological and yield characteristics compared to delayed planting.

The highest increase in plant height, number of productive tillers, panicle length, grain yield and proline content were 23.34, 22.52, 11.83, 44.71 and 11.24%, respectively in F5 fertilization (50 kg ha^{-1} KCl+2.5 ton ha^{-1} RSC+2.5 ton ha^{-1} CM), while the increase in the number of filled grain and thousand-grain weight of 35.64 and 10.53% were found in F4 fertilization (50 kg ha^{-1} KCl+5 ton ha^{-1} RSC) and an increase in total chlorophyll by 5.26% in fertilized with 2.5 ton ha^{-1} RSC+2.5 ton ha^{-1} CM (F3) compared to control. It was due to the RSC and CM had an organic-C (8.39 and 9.21%) and total-K_2O are higher than total-N and total-P_2O_5 that which can increase soil organic-C and affect the absorption of N, P, K nutrients and have an impact on the physiology of rice plants. It could be seen in the SPAD total chlorophyll of rice plants (physiological character) at the F2-F5 fertilizations were significantly different compared to F0 and F1 (Table 4). In addition, the SPAD total chlorophyll produced was significantly correlated with panicle length, the number of filled grains and thousand-grain weight in all rice varieties in rainfed lowland. These findings were supported by Ogbodo[20] that organic matter from plant residues can increase soil pH by increasing soil buffering capacity. Sudarsono *et al.*[22] and Teheri *et al.*[27] reported that the dose application of 10-15 ton ha^{-1} CM significantly increased the agronomy and physiological characteristics of rice. Rahman *et al.*[21] added that the RSC could increase the total-N, available-P and exchange-K by 60.00, 56.63% and 2.8 times, respectively.

The result also showed that the Inpago-9 variety had the highest number of productive tillers, number of filled grains, thousand-grain weight, grain yield and proline content

Table 3: F-test of planting dates (P), fertilization (F) and varieties (V) in a split-split-plot design

	F-value							
Source	PH	NPT	TC	PL	NFG	TGW	GY	PC
Replicate	0.96^{ns}	26.05*	0.14^{ns}	57.04*	0.60^{ns}	4.16*	5.26*	1.88^{ns}
Planting dates (P)	63.66*	190.69*	41.24*	203.12*	2831.86*	158.63*	933.21*	276.37*
Error (P)								
Fertilization (F)	75.69*	55.80*	32.18*	35.91*	290.42*	86.53*	136.33*	47.17*
P×F	1.19^{ns}	1.28^{ns}	1.73^{ns}	0.62^{ns}	11.74*	0.75^{ns}	9.51*	3.58*
Error (F)								
Varieties (V)	55.61*	43.65*	16.87*	58.49*	43.73*	32.55*	45.06*	252.30*
P×V	4.79*	6.17*	1.92*	6.84*	8.49*	1.31^{ns}	2.93*	0.73^{ns}
F×V	1.03^{ns}	0.78^{ns}	1.05^{ns}	1.31^{ns}	2.08*	2.17*	0.42^{ns}	3.80*
P×F×V	0.73^{ns}	0.53^{ns}	1.31^{ns}	1.11^{ns}	1.75*	0.73^{ns}	0.61^{ns}	1.65^{ns}
Error (V)								

*Indicated significantly different by DMRT at p<0.05, ns: Not significant, PH: Plant height, NPT: Number of productive tillers, TC: Total chlorophyll, PL: Panicle length, NFG: Number of filled grains, TGW: Thousand grain weight, GY: Grain yield and PC: proline content

Table 4: Effect of planting dates (P), fertilization (F) and varieties (V) on the growth, yield and proline content of rice plants under rainfed lowland

	Growth			Yield				
Treatment	PH (cm)	NPT	TC	PL (cm)	NFG	TGW (g)	GY (ton ha^{-1})	PC (μmol g^{-1})
Planting dates (P)								
P1	65.84[a]	11.41[a]	42.50[a]	24.72[a]	136.26[a]	26.10[a]	5.49[a]	60.88[c]
P2	60.11[b]	10.39[b]	41.65[b]	24.25[b]	100.17[b]	25.23[b]	3.91[b]	65.72[b]
P3	59.95[b]	9.28[c]	40.95[c]	22.31[c]	80.97[c]	24.15[c]	3.01[c]	70.94[a]
Fertilization (F)								
F0	54.53[d]	9.19[c]	40.28[b]	22.32[c]	87.26[c]	23.64[d]	3.31[c]	61.72[b]
F1	57.53[c]	9.58[c]	40.65[b]	22.70[c]	93.42[c]	24.29[c]	3.48[c]	62.70[b]
F2	62.42[b]	10.50[b]	42.37[a]	24.05[b]	109.09[b]	25.42[b]	4.27[b]	66.97[a]
F3	63.11[b]	10.58[b]	42.40[a]	24.12[b]	108.58[b]	25.44[b]	4.23[b]	66.65[a]
F4	66.96[a]	11.05[a]	42.19[a]	24.38[ab]	118.36[a]	26.13[a]	4.75[a]	68.39[a]
F5	67.26[a]	11.26[a]	42.31[a]	24.96[a]	118.10[a]	26.05[a]	4.79[a]	68.66[a]
Varieties (V)								
V1	62.76[b]	10.85[ab]	42.53[a]	22.55[d]	110.21[a]	25.32[bc]	4.46[a]	69.86[b]
V2	56.44[c]	10.53[ab]	42.51[a]	23.14[cd]	106.08[a]	25.49[b]	4.38[a]	70.11[ab]
V3	69.23[a]	8.87[d]	41.81[a]	25.50[a]	106.81[a]	24.76[d]	3.99[bc]	69.48[b]
V4	62.38[b]	10.68[ab]	40.89[b]	24.12[bc]	106.13[a]	24.55[de]	4.26[ab]	70.21[ab]
V5	68.49[a]	11.33[a]	41.77[a]	24.71[ab]	109.09[a]	26.41[a]	4.53[a]	71.34[a]
V6	62.84[b]	11.04[ab]	41.94[a]	24.55[ab]	106.61[a]	25.66[b]	4.46[a]	69.28[b]
V7	57.98[bc]	9.46[cd]	40.15[b]	22.51[d]	92.67[b]	24.16[e]	3.18[d]	51.52[d]
V8	55.62[c]	10.12[bc]	42.00[a]	22.96[cd]	108.80[a]	24.95[cd]	3.85[c]	54.99[c]

Values followed by different letters in the same column were significant based on the DMRT at $p<0.05$, PH: Plant height, NPT: Number of productive tillers, TC: Total chlorophyll, PL: Panicle length, NFG: Number of filled grain, TGW: Thousand grain weight, GY: Grain yield and PC: Proline content

compared to other varieties. The grain yield of the Inpago-9 variety was 4.53 ton ha^{-1} and classified as adaptive in rainfed lowland due to the high levels of proline produced compared to other varieties. The problem of drought in rainfed lowland rice increases several biochemical compounds such as proline levels as an adaptation mechanism. This finding was supported by Zhou *et al.*[28], Upadhyaya and Panda[29] that the expression of glutamate dehydrogenase provides drought tolerance in rice plants by preventing the accumulation of ammonia and increasing glutamate, proline, glycine betaine and soluble sugar compounds. Jauhari *et al.*[19] also found that upland rice plants of the Inpago-9 variety were classified as adaptive to rainfed lowland rice in Central Java with a yield was 5.38 ton ha^{-1}.

Interaction effect of planting dates and fertilization (P×F): The highest increase in the number of filled grain, grain yield and proline content in rice plants was due to the interactions of P1F4, P1F5 and P3F5 were 37.72, 39.55 and 16.17%, respectively compared to P1F0 and P3F0 (Table 5).

Interactions of P1F4 and P1F5 showed the highest number of filled grain and grain yield of rice plants under rainfed lowland compared to other interactions. The growth of rice plants at the interactions of P1F4 and P1F5 is assumed un-stressed by drought under rainfed lowland. It was due to the proline content produced in their interaction being lower compared to the other planting dates (P2 and P3) at the similar fertilization. Low contents of proline at an earlier planting indicate that rice plants are un-stressed by drought under rainfed lowlands, thus producing higher biomass. These findings were supported by Jaleel *et al.*[30] that proline accumulation can be used as a selection parameter for stress tolerance. Saha *et al.*[12] reported that drought stress could increase proline accumulation in the leaves of BRRI dhan-30, BRRI dhan-32, BRRI dhan-34, BRRI dhan-38 and BRRI dhan-56 varieties by 56.14, 85.1%, 1.4-, 1.1- and 3.7 times, respectively. Pal *et al.*[31] added that a decrease in nitrogen translocation, leaf area index, total-N uptake and grain yield of rice plants for PR-121, RIL-367 and RIL-1649 genotypes due to delayed planting from June, 1st to 20th. Chandini *et al.*[32] also found a decrease in dry weight and grain yield of rice plants due to differences in planting dates from August 5th to 21st. In addition, the KCl fertilizer treated with organic fertilizer (RSC and CM) at the early planting (P1) is assumed to increase nutrient uptake in rice plants. This result was supported by Iqbal *et al.*[33] that the combination of nitrogen (N) fertilizer with organic fertilizers (60+40% CM+N, 30+70% CM+N and 60+40% poultry manure/PM+N, 30+70% PM+N) significantly increased organic-C, total-N, nitrogen availability and translocation, harvest age, panicle length, panicle number, filled grain and grain yield of rice plants compared to control and 100% nitrogen fertilizer.

Interaction effect of planting dates and varieties (P×V): The highest increase in plant height, number of productive tillers and grain yield at the interaction of P1V5 (early planting with the Inpago-9 variety) and an increase in total chlorophyll, panicle length and number of filled grain at the

Table 5: Interaction effect of planting dates and fertilization (P×F) on the growth, yield and proline content in rice plants under rainfed lowland.

		Growth			Yield				
P	F	PH	NPT	TC	PL	NFG	TGW	GY	PC
P1	F0	57.34	10.10	40.98	23.09	111.16^{f}	24.47	4.45^{de}	57.47^{f}
	F1	60.68	10.49	41.29	23.22	118.05^{d}	25.12	4.62^{cd}	56.88^{f}
	F2	66.80	11.69	43.10	24.78	143.39^{c}	26.39	5.80^{b}	62.43^{e}
	F3	65.88	11.44	43.29	25.54	142.15^{c}	26.48	5.73^{b}	61.96^{e}
	F4	72.44	12.36	43.35	25.48	153.09^{a}	27.21	6.16^{a}	63.21^{de}
	F5	71.94	12.40	42.97	26.18	149.73^{b}	26.94	6.21^{a}	63.33^{de}
P2	F0	52.64	9.13	39.98	22.80	82.35^{l}	23.77	2.95^{hi}	62.57^{e}
	F1	55.71	9.55	40.34	23.41	90.47^{hi}	24.45	3.12^{gh}	64.18^{de}
	F2	60.35	10.44	42.39	24.70	100.82^{g}	25.30	3.97^{e}	66.60^{c}
	F3	61.34	10.89	42.94	24.63	101.07^{g}	25.57	4.03^{e}	67.04^{c}
	F4	64.86	10.94	41.89	24.85	111.89^{ef}	25.96	4.70^{c}	66.94^{c}
	F5	65.78	11.41	42.36	25.08	114.44^{ef}	26.31	4.71^{c}	67.01^{c}
P3	F0	53.60	8.34	39.88	21.05	68.26^{n}	22.66	2.52^{j}	65.11^{cd}
	F1	56.21	8.69	40.31	21.48	71.76^{m}	23.30	2.70^{ij}	67.05^{c}
	F2	60.11	9.39	41.63	22.68	83.05^{jkl}	24.55	3.06^{h}	71.88^{b}
	F3	62.13	9.43	40.97	22.20	82.51^{kl}	24.28	2.92^{hi}	70.95^{b}
	F4	63.59	9.85	41.32	22.82	90.09^{i}	25.23	3.40^{fg}	75.02^{a}
	F5	64.06	9.96	41.60	23.62	90.13^{hi}	24.91	3.44^{f}	75.64^{a}

Values followed by different letters in the same column were significant based on the DMRT at $p<0.05$, PH: Plant height, NPT: Number of productive tillers, TC: Total chlorophyll, PL: Panicle length, NFG: Number of filled grain, TGW: Thousand grain weight, GY: Grain yield and PC: proline content

Table 6: Interaction effect of planting dates and varieties (P×V) on the growth, yield and proline content in rice plants under rainfed lowland

		Growth			Yield				
P	V	PH	NPT	TC	PL	NFG	TGW	GY	PC
P1	V1	68.03^{a-p}	11.48^{abc}	42.71^{abc}	24.00^{e-h}	139.43^{a}	25.99	5.90^{a}	64.81
	V2	58.62^{j-q}	11.07^{bcd}	43.83^{a}	24.30^{d-g}	138.17^{a}	26.41	5.82^{a}	66.11
	V3	75.67^{ab}	10.03^{ef}	42.66^{abc}	26.07^{a}	139.15^{a}	26.00	5.07^{b}	64.39
	V4	66.52^{a-q}	11.57^{abc}	42.28^{abc}	24.93^{bcd}	139.51^{a}	25.68	5.71^{a}	65.67
	V5	76.33^{a}	12.08^{a}	42.60^{abc}	25.42^{ab}	138.50^{a}	27.15	6.01^{a}	66.77
	V6	66.10^{a-q}	11.73^{ab}	43.14^{abc}	24.55^{c-f}	138.30^{a}	26.58	5.89^{a}	63.71
	V7	60.07^{g-q}	11.63^{abc}	40.46^{abc}	24.18^{d-h}	115.53^{a-e}	25.07	4.20^{c}	46.45
	V8	55.42^{opq}	11.70^{abc}	42.30^{abc}	24.27^{d-h}	141.51^{a}	25.92	5.35^{b}	49.13
P2	V1	60.03^{h-q}	11.00^{cd}	42.96^{abc}	22.67^{jk}	111.18^{b-h}	25.42	4.37^{c}	69.50
	V2	54.50^{pq}	10.67^{de}	42.16^{abc}	23.73^{fgh}	102.48^{e-k}	25.33	4.09^{cd}	70.17
	V3	68.38^{a-p}	8.63^{h}	41.57^{abc}	26.05^{a}	95.44^{h-o}	24.49	3.87^{d}	69.56
	V4	61.38^{d-p}	10.63^{de}	40.55^{abc}	25.33^{abc}	97.36^{g-o}	24.66	4.03^{cd}	70.58
	V5	64.17^{a-q}	11.60^{abc}	42.00^{abc}	25.22^{bc}	102.91^{d-k}	26.79	4.28^{c}	71.29
	V6	61.60^{c-q}	11.10^{bcd}	41.89^{abc}	24.58^{cde}	97.85^{f-n}	25.59	4.17^{cd}	69.09
	V7	57.15^{l-q}	9.37^{g}	40.20^{abc}	22.90^{ij}	89.92^{i-q}	24.28	2.99^{fg}	50.83
	V8	53.68^{q}	10.13^{ef}	41.87^{abc}	23.48^{hi}	104.25^{c-l}	25.27	3.52^{e}	54.77
P3	V1	60.22^{f-q}	10.07^{ef}	41.92^{abc}	20.98^{mn}	80.02^{opq}	24.55	3.10^{f}	75.27
	V2	56.20^{n-q}	9.87^{fg}	41.56^{abc}	21.40^{lm}	77.59^{pq}	24.73	3.23^{ef}	74.07
	V3	63.65^{a-q}	7.93^{ij}	41.19^{abc}	24.38^{def}	85.85^{j-q}	23.78	3.03^{fg}	74.50
	V4	59.23^{i-q}	9.83^{fg}	39.82^{bc}	22.10^{kl}	81.52^{m-q}	23.31	3.05^{fg}	74.38
	V5	64.98^{a-q}	10.32^{ef}	40.71^{abc}	23.50^{ghi}	85.84^{k-q}	25.28	3.29^{ef}	75.96
	V6	60.83^{e-q}	10.28^{ef}	40.79^{abc}	24.53^{c-f}	83.69^{l-q}	24.79	3.31^{ef}	75.03
	V7	56.73^{m-q}	7.37^{j}	39.79^{c}	20.45^{n}	72.57^{q}	23.13	2.37^{h}	57.27
	V8	57.75^{k-q}	8.53^{hi}	41.83^{abc}	21.12^{mn}	80.65^{n-q}	23.66	2.68^{gh}	61.06

Values followed by different letters in the same column were significant based on the DMRT at $p<0.05$, PH: Plant height, NPT: Number of productive tillers, TC: Total chlorophyll, PL: Panicle length, NFG: Number of filled grain, TGW: Thousand grain weight, GY: Grain yield and PC: Proline content

interaction of early planting with the Towuti (P1V2), Batutegi (P1V3) and Inpari-10 (P1V8) varieties (Table 6).

It was due to the earlier planting resulting in higher biomass production and has an impact on increasing grain yields. These results could be presented by plant height, number of productive tillers, total chlorophyll, panicle length, number of filled grains and thousand-grain weight which have a significant correlation to the grain yield in Towuti, Batutegi, Inpago-9 and Inpari-10 varieties. This finding was supported by Pal *et al.*[31] that the grain yield of rice plants at early planting is highly correlated ($r = 0.91$) with biomass compared to delayed planting ($r = 0.82$). Limouchi[34] also reported that the

Table 7: Interaction effect of fertilization and varieties (F×V) on growth, yield and proline content in rice plants under rainfed lowland

		Growth			Yield				
F	V	PH	NPT	TC	PL	NFG	TGW	GY	PC
F0	V1	55.30	9.43	41.46	20.82	90.38^{o-x}	23.63^{o-r}	3.74	67.43^{j-n}
	V2	50.63	9.53	40.48	21.79	89.21^{q-x}	24.47^{j-o}	3.59	64.68^{m-p}
	V3	58.83	7.93	39.58	23.35	87.82^{u-x}	23.73^{n-q}	3.12	62.97^{op}
	V4	55.73	9.57	39.94	22.22	86.26^{vwx}	23.44^{o-r}	3.39	69.40^{e-l}
	V5	57.57	9.97	39.73	23.11	89.13^{r-x}	24.41^{j-o}	3.62	66.19^{k-o}
	V6	56.43	9.87	40.77	23.11	88.24^{s-x}	22.99^{qr}	3.57	64.29^{nop}
	V7	51.40	8.23	39.47	21.74	79.08^{x}	23.70^{n-q}	2.49	48.75^{t}
	V8	50.30	8.97	40.82	22.38	87.93^{t-x}	22.72^{r}	2.93	50.02st
F1	V1	60.00	9.87	40.82	21.49	93.29^{m-x}	24.51^{i-n}	3.70	65.36^{l-p}
	V2	52.47	9.87	41.51	21.93	94.25^{l-x}	24.66^{h-n}	3.78	66.88^{j-o}
	V3	62.60	8.10	40.97	24.22	92.95^{n-x}	24.36^{m-p}	3.25	68.16^{h-n}
	V4	58.50	10.00	39.82	22.95	96.09^{g-x}	24.03^{g-l}	3.62	66.75^{j-o}
	V5	61.93	10.80	40.47	23.64	96.03^{h-x}	25.17^{g-l}	4.06	67.72^{i-n}
	V6	58.73	10.20	40.77	23.38	94.83^{k-x}	24.12^{l-p}	3.72	64.66^{m-p}
	V7	53.87	8.63	39.58	22.10	84.46^{wx}	23.33^{pqr}	2.51	48.35^{t}
	V8	52.17	9.13	41.26	21.92	95.50^{i-x}	24.15^{l-p}	3.17	53.75^{qrs}
F2	V1	62.33	11.20	42.59	22.79	114.06^{a-f}	25.16^{g-l}	4.57	68.14^{h-n}
	V2	57.23	10.73	43.96	22.86	111.33^{a-l}	25.34^{g-k}	4.53	71.75^{b-l}
	V3	71.37	8.80	42.54	26.42	110.96^{a-m}	24.91^{g-m}	4.02	67.74^{i-n}
	V4	63.17	10.93	41.11	25.02	108.59^{b-n}	24.90^{g-m}	4.49	69.03^{f-l}
	V5	69.30	11.40	42.34	24.61	113.92^{a-h}	27.20^{ab}	4.58	74.47^{abc}
	V6	62.53	11.27	43.47	24.81	108.03^{c-o}	25.91^{c-g}	4.72	73.65^{a-d}
	V7	57.00	9.23	40.61	22.87	94.91^{j-x}	24.27^{k-p}	3.23	54.95^{qr}
	V8	56.43	10.47	42.35	23.05	110.91^{a-m}	25.63^{d-h}	4.03	56.02^{qr}
F3	V1	63.17	11.33	43.40	23.29	111.92^{a-l}	25.27^{g-k}	4.66	72.07^{b-h}
	V2	57.20	10.10	43.18	24.43	104.56^{e-u}	25.47^{e-j}	4.53	68.72^{g-m}
	V3	69.13	8.87	42.54	25.32	110.04^{a-n}	25.11^{g-l}	4.01	73.93^{a-d}
	V4	63.70	11.07	41.92	24.02	112.13^{a-l}	24.58^{h-n}	4.35	73.65^{a-d}
	V5	72.37	11.83	42.97	25.51	115.81^{a-f}	26.40^{b-f}	4.63	69.95^{d-k}
	V6	63.50	11.70	41.97	24.91	111.48^{a-l}	26.48^{b-e}	4.59	70.11^{d-k}
	V7	58.67	9.70	40.53	22.41	89.80^{p-x}	24.42^{j-o}	3.32	53.84^{qrs}
	V8	57.17	10.07	42.69	23.12	112.87^{a-l}	25.80^{c-g}	3.72	50.95st
F4	V1	68.13	11.53	43.26	23.22	124.01^{a-d}	26.69^{bc}	5.03	74.27^{abc}
	V2	60.63	11.17	42.83	23.99	124.08^{a-d}	26.59^{bcd}	4.86	75.70^{ab}
	V3	75.97	10.00	42.55	26.75	121.14^{a-e}	25.44^{f-j}	4.75	71.81^{b-h}
	V4	67.17	11.07	41.19	24.65	119.30^{a-e}	25.79^{c-g}	4.81	70.55^{c-j}
	V5	72.50	11.90	43.09	25.34	118.41^{a-f}	27.38^{ab}	5.14	76.36^{a}
	V6	68.57	11.70	41.94	24.98	119.71^{a-e}	27.11^{ab}	5.05	70.61^{c-j}
	V7	63.40	10.07	40.03	22.90	100.81^{f-w}	24.61^{h-n}	3.72	50.38st
	V8	59.33	10.97	42.64	23.22	119.41^{a-e}	25.46^{e-j}	4.65	57.46^{q}
F5	V1	67.63	11.73	43.65	23.69	127.61^{a}	26.67^{bc}	5.02	71.88^{b-h}
	V2	60.47	11.80	43.13	23.86	113.05^{a-l}	26.42^{b-f}	4.96	72.97^{a-f}
	V3	77.50	9.50	42.68	26.95	117.97^{a-f}	24.99^{g-m}	4.79	72.30^{b-g}
	V4	66.00	11.43	41.34	25.85	114.40^{a-f}	24.57^{d-l}	4.91	71.90^{b-h}
	V5	77.30	12.10	42.02	26.07	121.22^{a-e}	27.88^{a}	5.13	73.34^{a-e}
	V6	67.30	11.50	42.73	26.14	117.40^{a-f}	27.32^{ab}	5.07	72.35^{a-g}
	V7	63.57	10.87	40.69	23.04	106.97^{d-r}	24.63^{h-n}	3.82	52.85^{rs}
	V8	58.30	11.13	42.25	24.05	126.20^{ab}	25.94^{c-g}	4.61	61.71^{p}

Values followed by different letters in the same column were significant based on the DMRT at $p<0.05$, PH: Plant height, NPT: Number of productive tillers, TC: Total chlorophyll, PL: Panicle length, NFG: Number of filled grain, TGW: Thousand grain weight, GY: Grain yield and PC: Proline content

interaction of planting dates with varieties significantly increased panicle dry weight and had a highly correlated (0.759) between panicle dry weight within grain yield of rice plants.

Interaction effect of fertilization and varieties (F×V): The highest increase in proline content, thousand-grain weight and the number of filled grains in the F4V5, F5V5 and F5V1 interactions were 15.36, 14.22 and 41.19%, respectively compared to F0V5 and F0V1 (Table 7).

It was shown that the combination of chemical+organic fertilization (KCl+RSC, KCl+CM) at different doses can support the growth of rice plants (Inpago-9 and Situ Bagendit) under rainfed lowland. It could be seen by the total chlorophyll of

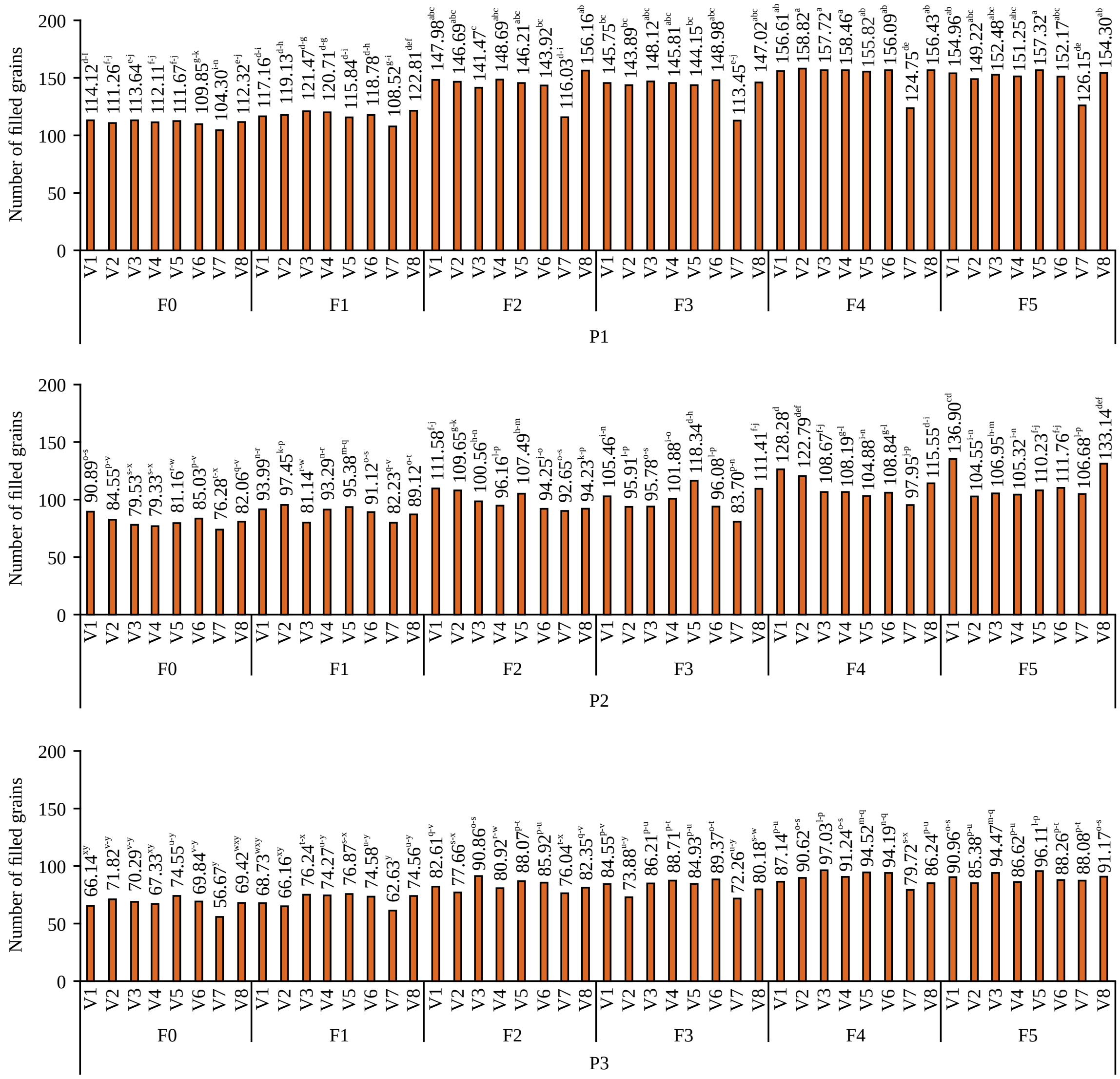

Fig. 1: Interaction effect of planting dates, fertilization and varieties (P×F×V) on the number of filled grains in rice plants under rainfed lowland

rice plants due to F2-F5 fertilization (RSC, RSC+CM, KCl+RSC, KCl+RSC+CM) significantly increased compared to control or single chemical fertilization (Table 4). It was assumed that the total chlorophyll content affected rice yield, which was indicated by a significantly correlated to panicle length, number of filled grains, thousand-grain weight and grain yield in Inpago-9 and Situ Bagendit varieties. According to Iqbal *et al*.[35] the combination of chemical fertilizers (CF) with organic fertilizers (60+40, 30+70% CM+CF and 60+40, 30+70% PM+CF) significantly increased soil pH, organic-C, total-N, nutrients availability (nitrogen, phosphorus, potassium), net photosynthetic rate, nitrogen translocation, panicle length and filled grain of rice compared to control and 100% CF.

Interaction effect of planting dates, fertilization and varieties (P×F×V): The interactions of P1F4V2, P1F4V3, P1K4V4 and P1F5V5 significantly increased the number of filled grains of rice was significant to other interactions (Fig. 1).

It was due to the combination of chemical and organic fertilizers that can increase soil fertility and have an impact on the accumulation of biomass at earlier planting with Towuti, Batutegi, Inpago-8 and Inpago-9 varieties which resulted in a higher number of filled grain. It could be seen the plant height, the number of productive tillers, total chlorophyll and panicle length were significantly correlated to the number of filled grains in the four varieties. The highest correlation value was found in the total chlorophyll. It was indicated that the number of filled grain in the P×F×V interactions was strongly

Table 8: Correlation between parameters due to the interactions of planting dates, fertilization and rice varieties under rainfed lowland

Rice varieties		PH	NPT	TC	PL	NFG	TGW	GY	PC
Situ Bagendit	PH	1	0.596**	0.420*	0.331*	0.509**	0.855**	0.193	0.046
	NPT		1	0.665**	0.388*	0.553**	0.580**	0.159	0.189
	TC			1	0.505**	0.490**	0.504**	0.188	0.335*
	PL				1	0.605**	0.413*	0.532**	-0.142
	NFG					1	0.679**	0.456**	-0.266
	TGW						1	0.238	0.124
	GY							1	-0.310
	PC								1
Towuti	PH	1	0.488**	0.496**	0.289	0.461**	0.745**	0.374*	0.224
	NPT		1	0.482**	0.370*	0.461**	0.553**	0.478**	0.392*
	TC			1	0.394*	0.561**	0.552**	0.645**	0.110
	PL				1	0.515**	0.382*	0.602**	-0.027
	NFG					1	0.808**	0.899**	-0.055
	TGW						1	0.717**	0.221
	GY							1	0.009
	PC								1
Batutegi	PH	1	0.471**	0.205	0.351*	0.552**	0.788**	0.361*	0.037
	NPT		1	0.574**	0.254	0.748**	0.666**	0.772**	0.020
	TC			1	0.532**	0.571**	0.369*	0.712**	0.165
	PL				1	0.436**	0.259	0.511**	0.008
	NFG					1	0.753**	0.848**	-0.138
	TGW						1	0.578**	-0.001
	GY							1	-0.054
	PC								1
Inpago-8	PH	1	0.456**	0.714**	0.226	0.563**	0.630**	0.391*	-0.056
	NPT		1	0.556**	0.234	0.480**	0.547**	0.544**	0.286
	TC			1	0.327	0.775**	0.685**	0.689**	-0.143
	PL				1	0.463**	0.348*	0.525**	-0.115
	NFG					1	0.731**	0.912**	-0.355*
	TGW						1	0.635**	-0.032
	GY							1	-0.283
	PC								1
Inpago-9	PH	1	0.422*	0.616**	0.385*	0.631**	0.677**	0.429**	-0.015
	NPT		1	0.588**	0.352*	0.625**	0.651**	0.681**	0.185
	TC			1	0.461**	0.657**	0.680**	0.574**	-0.022
	PL				1	0.547**	0.545**	0.560**	0.014
	NFG					1	0.774**	0.894**	-0.107
	TGW						1	0.695**	0.277
	GY							1	-0.071
	PC								1
Inpago-10	PH	1	0.381*	0.361*	0.259	0.535**	0.720**	0.371*	0.064
	NPT		1	0.695**	0.251	0.590**	0.607**	0.623**	0.212
	TC			1	0.273	0.712**	0.652**	0.819**	0.044
	PL				1	0.251	0.532**	0.281	0.339*
	NFG					1	0.720**	0.900**	-0.222
	TGW						1	0.699**	0.173
	GY							1	-0.152
	PC								1
Ciherang	PH	1	0.254	0.516**	0.184	0.481**	0.793**	0.435**	-0.029
	NPT		1	0.257	0.560**	0.801**	0.268	0.811**	-0.254
	TC			1	0.158	0.329	0.435**	0.267	-0.042
	PL				1	0.611**	0.369*	0.486**	-0.528**
	NFG					1	0.614**	0.827**	-0.418*
	TGW						1	0.490**	-0.313
	GY							1	-0.175
	PC								1
Inpari-10	PH	1	0.256	0.714**	0.009	0.185	0.622**	0.079	0.342*
	NPT		1	0.328	0.436**	0.704**	0.634**	0.708**	-0.113
	TC			1	0.077	0.299	0.630**	0.238	0.204
	PL				1	0.602**	0.451**	0.551**	-0.356*
	NFG					1	0.742**	0.903**	-0.238
	TGW						1	0.621**	0.033
	GY							1	-0.117
	PC								1

**and *Correlation is significant at the 0.01 and 0.05 levels, n: 36 samples, PH: Plant height, NPT: Number of productive tillers, TC: Total chlorophyll, PL: Panicle length, NFG: Number of filled grain, TGW: Thousand grain weight, GY: Grain yield and PC: Proline content influenced by the total chlorophyll of rice plants. According to Iqbal *et al.*[35] the combination of chemical fertilizers with organic fertilizers at different doses could increase soil pH, organic-C, total-N, nutrients availability (nitrogen, phosphorus, potassium) and increase the rice yield. Kumar *et al.*[36] added that the increase in chlorophyll content and net photosynthetic rate in seed filling required nutrients faster from chemical fertilizers, while organic fertilizers were slow and stable in providing nutrients throughout the entire growth period.

Correlation values: All characteristics of rice plants were due to the interactions of planting dates, fertilization and varieties under rainfed lowland (Table 8).

The plant height, number of productive tillers, total chlorophyll, panicle length, number of filled grain and thousand-grain weight were positively correlated with grain yield in all rice varieties under rainfed lowlands. However, proline contents were negatively correlated with grain yield in all varieties, except Towuti. It was the interaction of planting dates, fertilization and varieties that can support soil fertility and cause rice plants to be more adaptive to drought stress in rainfed lowland, thus proline content was negatively correlated with grain yields. Purbajanti *et al.*[11] found that an increase in drought stress caused a decrease in the number of tillers, stover weight, grain yield and chlorophyll content, but increased antioxidant, polyphenol and proline content in rice plants.

The outcomes of this study proved that rainfed lowland can be optimized through early planting, combining KCl fertilizer at a dose of 50 kg ha^{-1} with organic materials, such as rice straw compost and cattle manure at 2.5 tons ha^{-1} respectively. Among rice varieties, it is evident that upland rice, especially the Inpago-9 variety had a greater potential in responding to the early planting combined with potassium fertilizer and organic matter compared to lowland rice. The three efforts can be used as short- and long-term management techniques in improving soil fertility and rice yields in rainfed lowland.

CONCLUSION

The increase in the growth and yield characters of rice plants in rainfed lowland were greater found at an earlier planting (January 10th), F3-F5 fertilization (2.5+2.5 ton ha^{-1} RSC+CM, 50 kg ha^{-1} KCl+5 ton ha^{-1} RSC, 50 kg ha^{-1} KCl+2.5+2.5 ton ha^{-1} RSC+CM) and Inpago-9 variety. The interaction of P1F4 and P1F5 could increase the highest number of filled grains and grain yields were 37.72 and 39.55%. The interaction of P1V5 could increase the highest plant height, the number of productive tillers, grain yield and P1V2, P1V3, P1V8 interactions also increased total chlorophyll, panicle length and the number of filled grain. Based on the F×V interaction, the F5V5 and F5V1 could increase thousand-grain weight and the number of filled grains by 14.22 and 41.19%. The results also obtained that the interactions of P1F4V2, P1F4V3, P1F4V4 and P1F5V5 could increase the number of filled grains. There was a negative correlation between proline content and grain yield due to the interaction of the three treatments. These findings suggested that early planting with a combination of fertilization (KCl+RSC+CM) and the Inpago-9 variety can be used as an alternative to optimizing rice yield under rainfed lowland.

SIGNIFICANCE STATEMENT

About 27.5% of rice yields in Indonesia are found in rainfed lowland. The area covered by rainfed lowland should be managed to support food self-sufficiency through the planting date, potassium fertilizer both inorganic and organic and the use of several varieties of lowland and upland rice. It was found that earlier planting, organic potassium fertilizers combined with KCl and the Inpago-9 variety significantly increased the highest growth and yield of rice under rainfed lowland. These findings can be used as an important alternative for academics, farmers and stakeholders in mitigating rainfed fields.

ACKNOWLEDGMENTS

The authors would like to thank the Indonesian Agency for Agricultural Research and Development, the Ministry of Agriculture of the Republic of Indonesia for funding this study.

REFERENCES

1. Mulyani, A., B. Mulyanto, B. Barus, D.R. Panuju and Husnain, 2022. Analysis of rice field production capacity for National Food Security by 2045 [In Indonesian]. J. Sumberdaya Lahan, 16: 33-50.
2. Thanawong, K., S .R. Perreta and C. Basset-Mens, 2014. Eco-efficiency of paddy rice production in Northeastern Thailand: A comparison of rain-fed and irrigated cropping systems. J. Cleaner Prod., 73: 204-217.

3. Aleminew, A., G. Alemayehu, E. Adgo and T. Tadesse, 2019. Response of rain-fed lowland rice varieties to different sources of N fertilizer in Fogera Plain, Northwest Ethiopia. Cogent Food Agric., Vol. 5. 10.1080/23311932.2019.1707020.
4. Jonharnas, J.H. and S.H. Sitindaon, 2017. The role of rainfed areas for National Food Security at Deli Sedang District, North Sumatra [In Indonesian]. J. Agroteknologi, 7: 15-20.
5. Kasno, A., T. Rostaman and D. Setyorini, 2016. Increasing productivity of rainfed area with N, P, and K fertlizers and use of high yielding varieties. J. Tanah Iklim, 40: 147-157.
6. Rohaeni, W.R. and U. Susanto, 2017. Agronomical performance and genetic parameter estimation of 100 rice advance lines on drought stress condition [In Indonesian]. J. Agro, 4: 110-119.
7. Sahrawat, K.L., 2005. Iron toxicity in wetland rice and the role of other nutrients. J. Plant Nutr., 27: 1471-1504.
8. Jawang, U.P., 2021. Assessment of fertility status and management of rain-fed rice fields in Umbu Pabal Selatan Village, Umbu Ratu Nggay Barat District [In Indonesian]. J. Ilmu Pertanian Indonesia, 26: 421-427.
9. Benauli, A., 2021. Study of the nutrient status of N, P, K in rainfed ricefields (case study of three villages in Beringin District) [In Indonesian]. Agrosains: J. Penelitian Agronomi, 23: 55-59.
10. Boling, A., T.P. Tuong, S.Y. Jatmiko and M.A. Burac, 2004. Yield constraints of rainfed lowland rice in Central Java, Indonesia. Field Crops Res., 90: 351-360.
11. Purbajanti, E.D., F. Kusmiyati and E. Fuskhah, 2017. Growth, yield and physiological characters of three types of Indonesian rice under limited water supply. Asian J. Plant Sci., 16: 101-108.
12. Saha, S., H.H. Begum and S. Nasrin, 2019. Effects of drought stress on growth and accumulation of proline in five rice varieties (*Oryza sativa* L.). J. Asiatic Soc. Bangladesh Sci., 45: 241-247.
13. Mustamu, N.E., K. Tampubolon, Alridiwirsah, M. Basyuni, D.K.A. AL-Taey, H.J.K. AL Janabi and M. Mehdizadeh, 2023. Drought stress induced by polyethylene glycol (PEG) in local maize at the early seedling stage. Heliyon, Vol. 9. 10.1016/j.heliyon.2023.e20209.
14. Kwesiga, J., K. Grotelüschen, K. Senthilkumar, D. Neuhoff, T.F. Döring and M. Becker, 2020. Effect of organic amendments on the productivity of rainfed lowland rice in the Kilombero floodplain of Tanzania. Agronomy, Vol. 10. 10.3390/agronomy10091280.
15. Satapathy, S.M., V.K. Srivastava, P.K. Majhi and S. Gond, 2021. Effect of delayed time of planting on grain yield and agro-morphological traits of elite rice (*Oryza sativa* L.) varieties. Int. J. Plant Soil Sci., 33: 68-79.
16. Wihardjaka, A., E.S. Harsanti and A.N. Ardiwinata, 2022. Effect of fertilizer management on potassium dynamics and yield of rainfed lowland rice in Indonesia. Chil. J. Agric. Res., 82: 33-43.
17. Mukesh, S. Ishwar, R.K. Pannu, P. Dasharath and R. Asha, 2013. Effects of different transplanting dates on yield and quality of basmati rice (*Oryza sativa*) varieties. Indian J. Agron., 58: 256-258.
18. Rahim, S., W.B. Suwarno and H. Aswidinnoor, 2023. Genotype by environment interaction of IPB new plant type rice lines in three irrigated lowland locations. Agrivita. J. Agric. Sci., 45: 163-172.
19. Jauhari, S., E. Winarni and D. Sahara, 2020. Growth and productivity performance of new superior varieties upland rice in rain-fed rice fields in Semarang District, Central Java [In Indonesian]. J. Pangan, 29: 25-34.
20. Ogbodo, E.N., 2011. Effect of crop residue on soil chemical properties and rice yield on an ultisol at Abakaliki, Southeastern Nigeria. World J. Agric. Sci., 7: 13-18.
21. Rahman, F., M. Mizanur Rahman, G.K.M. Mustafizur Rahman, M.A. Saleque, A.T.M.S. Hossain and M.G. Miah, 2016. Effect of organic and inorganic fertilizers and rice straw on carbon sequestration and soil fertility under a rice-rice cropping pattern. Carbon Manage., 7: 41-53.
22. Sudarsono, W.A., M. Melati and S.A. Aziz, 2014. Growth and yield of organic rice with cow manure application in the first cropping season. AGRIVITA, 36: 19-25.
23. Andrias, Suprihati and D. Setyorini, 2016. Assembly technology of specific location nutrient management for Gogo Rancah system-based Paddy at Semawung Village in the Sub-District of Andongboyolali Regency. Agric, 28: 31-40.
24. SRI, 2005. Technical Instructions For Chemical Analysis of Soil, Plants, Water and Fertilizer [In Indonesian]. Bogor Soil Research Institute, Bogor, Indonesia, ISBN: 9789799474513, Pages: 136.
25. Bates, L.S., R.P. Waldren and I.D. Teare, 1973. Rapid determination of free proline for water-stress studies. Plant Soil, 39: 205-207.
26. Khalifa, A.A.B.A., 2009. Physiological evaluation of some hybrid rice varieties under different sowing dates. Aust. J. Crop Sci., 3: 178-183.
27. Taheri, R.E., M.H. Ansari and N.A. Razavi, 2018. Influence of cow manure and its vermicomposting on the improvement of grain yield and quality of rice (*Oryza sativa* L.) in field conditions. Appl. Ecol. Environ. Res., 16: 97-110.
28. Zhou, Y., C. Zhang, J. Lin, Y. Yang and Y. Peng *et al*., 2015. Over-expression of a glutamate dehydrogenase gene, *MgGDH*, from *Magnaporthe grisea* confers tolerance to dehydration stress in transgenic rice. Planta, 241: 727-740.
29. Upadhyaya, H. and S.K. Panda, 2019. Drought Stress Responses and Its Management in Rice. In: Advances in Rice Research for Abiotic Stress Tolerance, Hasanuzzaman, M., M. Fujita, K. Nahar and J.K. Biswas (Eds.), Woodhead Publishing, Cambridge, ISBN: 9780128143322, pp: 177-200.

30. Jaleel, C.A., R. Gopi, B. Sankar, P. Manivannan, A. Kishorekumar, R. Sridharan and R. Panneerselvam, 2007. Studies on germination, seedling vigour, lipid peroxidation and proline metabolism in *Catharanthus roseus* seedlings under salt stress. South Afr. J. Bot., 73: 190-195.
31. Pal, R., G. Mahajan, V. Sardana and B.S. Chauhan, 2017. Impact of sowing date on yield, dry matter and nitrogen accumulation, and nitrogen translocation in dry-seeded rice in North-West India. Field Crops Res., 206: 138-148.
32. Chandini, A. Sen, V.K. Srivastava, A. Sankar and M. Sahoo, 2020. Effect of planting dates on dry weight, flowering and yield of different rice varieties. J. Pharmacogn. Phytochem., 9: 1394-1397.
33. Iqbal, A., L. He, I. Ali, Saif Ullah and A. Khan *et al*., 2020. Manure combined with chemical fertilizer increases rice productivity by improving soil health, post-anthesis biomass yield, and nitrogen metabolism. PLoS ONE, Vol. 15. 10.1371/journal.pone.0238934.
34. Limouchi, K., 2018. Evaluating the effect of different planting dates on panicle growth trend and performance of rice varieties in Khuzestan Region, Iran. J. Appl. Sci. Environ. Manage., 22: 1397-1402.
35. Iqbal, A., L. He, I. Ali, Saif Ullah and A. Khan *et al*., 2021. Co-incorporation of manure and inorganic fertilizer improves leaf physiological traits, rice production and soil functionality in a paddy field. Sci. Rep., Vol. 11. 10.1038/s41598-021-89246-9.
36. Kumar, K.A., D.K. Swain and P.B.S. Bhadoria, 2018. Split application of organic nutrient improved productivity, nutritional quality and economics of rice-chickpea cropping system in lateritic soil. Field Crops Res., 223: 125-136.