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Effect of Seedling Age and Potassium Rates on Morphological Traits Related-Lodging, Yield and Yield Components of Rice (*Oryza sativa* L.) In Iran

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Abstract: In order to investigate the effect of seedling age and potassium rates on morphological traits related-lodging on yield and yield components in rice, an experiment was carried out at split plot in randomized complete block design with four replications in Mazandaran province (Iran) in 2009. Main plots was seedling age in three levels including 20, 30 and 40 days and sub plots was potassium rates in four levels including 0, 30, 60 and 90 kg K ha^{-1}. Results showed that grain yield had significant difference in seedling ages. Grain yield of 20 and 30 days old seedling was minimum and maximum with 635 and 846 g. m^{-2}, respectively. High potassium application decreased the harvest index and increased the biological yield. Number of effective tillers per plant was effected by potassium rate and was significant at $p<0.05$ and for 90 Kg K ha^{-1} 12.59 and for control 14.60 tillers were produced. Panicle numbers with potassium application was lower than control. Potassium increased plant height and panicle length. The longest third and fourth internodes were observed at 40 day-old seedlings (17.12 and 28.49 cm) and the shortest third and fourth internodes also seen at 20 day-old seedling which was 12.47 and 21.21 cm, respectively.

Key words: Rice・Potassium・Seedling age・Lodging・Grain yield

INTRODUCTION

Age of seedlings at transplanting most often depended on the availability of water, herbicides, labor and other inputs in farmers' fields. In tropical lowland rice, farmers transplant seedlings at distinct ages, most of the time from 25 to 50 days after germination [1]. Some studies indicated a positive impact on grain yield by using seedlings not older than 25 days [2]. On the other hand, few others reported that the use of 30- and 60-day-old seedlings did not affect yield [3], whereas, using 45-day-old seedlings proved to be better than those aged 30, 60 and 75 days [4]. Some attributed the significant superiority in 1000-grain weight and grain yield of younger seedlings (25 days old versus 50 days old) to the heading and maturity periods [5]. While others attributed it to the longer vegetative growth [6]. Recent studies on the System of Rice Intensification (SRI) showed, however, that transplanting seedlings as young as about 14 days old generated higher crop performance than transplanting 21- to 23-day-old seedlings [6]. McHugh, [7] also observed in Madagascar that 8- to 15-day-old seedlings transplanted at 25 hills m^{-2} produced the highest yields, whereas in Sumatra the highest yields were obtained with 10-day-old transplanted seedlings. In North Sumatra, a 15-day-old seedling crop out yielded a 21-day-old one [6]. There were indications that the longer stay of seedlings in the nursery may have affected seedling growth pattern in response to high seedling competition [8].

Herrera and Zandstra [9] also stated that transplanting old seedlings extended the overall crop duration. Producing vigorous seedlings from desirable nurseries in order to increase grain yield was also the focus of recent work on improving nursery management with the assumption that high seedling vigor mostly depends on the kind of nursery the plants are grown in. Although seedlings are grown at 4000 seeds m^{-2} and transplanted at 20-25 days old under conventional

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wet-bed nurseries, or grown at 120,000 seeds m^{-2} and transplanted at 9-14 days old under dapog nurseries [10]. Rajendran *et al.* [11] reported that higher seedling vigor with regard to seedling dry weight and seed germination rate due to the development of an improved mat nursery. This nursery was, however, characterized by a highly fertile medium with urea supply, a low seed rate (2000-4000 seeds m^{-2}) and the transplanting of 14-day-old seedlings in contrast to the conventional wet-bet nursery. These confounding effects did not allow quantifying the individual benefit of each component. Sanchez and Larrea, [12] showed that delayed transplanting reduced plant height and dry matter production caused flowering shortly after transplanting in some cases and decreased panicle production and the number of fertile grains per panicle. Sanchez and Larrea [12] indicated that IR8 produced the highest grain yield (12.0 t/ha) when transplanted at 30 days after seeding and yields decreased linearly at the rate of 125 kg/ha per day of delayed transplanting beyond 30 days. Also, Sanchez and Larrea, [12] founded that 'Minabir' variety less pronounced yield decreases up to 75 days after seeding. Slowing seedbed growth of IR8 through water and nitrogen stress produced significant yield increases when transplanted at 75 and 90 days after seeding.). However, results of scientific works were not consistent that it is seem that depended weather condition, soil nutrition, rice cultivar, irrigation system or plant system (Low land or upland) and plant density.

Elliot *et al.* [13] indicated that potassium deficient rice is susceptible to diseases including stem rot (*Sclerotium oryzae* Catt.). Elliot *et al.* [13] showed that potassium fertilization increased grain yield by 8 to 11% above rice receiving no K. Slaton *et al.* [14] founded that rice having whole-plant K concentrations of 23.1 g kg^{-1} at panicle differentiation and 13.0 g kg^{-1} at early heading were predicted to produce 95% relative yield. The predicted K-fertilizer rates required to optimize rice grain yield depended on the model and ranged from 51 to 90, 41 to 70, 30 to 55 and 20 to 35 kg K ha^{-1} for soil having Mehlich-3 soil K concentrations of 60, 70, 80 and 90 mg K kg^{-1}, respectively. K uptake by plants is similar to that of N, however and is usually an order of magnitude greater than that for P [15]. Potassium and stover management are critical to the uplands of Sitiung, Indonesia, where the predominant cropping system is upland rice followed by soybean or peanuts [16]. Elliot *et al.* [13] founded that potassium fertilizer applied between panicle differentiation and late boot can reduce yield losses from K deficiency. Although soil acidity and low soil P are the major fertility constraints in soils Ultisols and Oxisols, K usually becomes limiting to crop growth under continuous cultivation [17]. Dierolf and Yost, [18] showed that soil and crop management factors also contribute to the occurrence of K deficiency. For example, in the move to intensify crop production on highly weathered soils, K application usually ranks far behind N and P [19].

Additionally, removing crop stover from the field hastens the depletion of soil K [20]. Although K can be replenished through fertilization, excessive fertilization can result in leaching losses [21] and in losses from the luxury consumption of K [22] when stover is not returned [18]. Also, Dierolf and Yost [18] showed that rice straw in upland rice system is usually burned in piles after threshing. Even if farmers rotate the location of the rice burn piles each season, incorporation of burnt stover generally results in an uneven distribution of nutrients, which can hasten nutrient depletion [18]. The large concentration of cations in one area may exceed the soil effective cation exchange capacity and render the nutrient cations susceptible to leaching losses [23]. The objectives of this experiment were to (i) evaluate seedling age and potassium rates on morphological characteristics related-lodging (ii) effects of seedling age and potassium rates on yield and yield components of rice.

MATERIALS AND METHODS

Field experiments were conducted in the growth season of 2009 at the farm of the Research Institute, Behshahr (36 37 N, 53 11 E, 13 m altitude), Iran. The precipitation and evaporation were 750 and 1750, respectively that maximum rain in Sep. with 42 mm and minimum was in Jun with 0.3 mm (Table 1). The soil of the field is silt clay with pH 7.3, 0.5% organic matter, 0.32 % total N, 9 ppm P, 185 ppm extractable K and 0.91 μmohs EC (Table 2). The soil tests were based on samples taken from the upper 20 cm of the soil.

The preceding crop was rice. The experiment was carried out in split-plot that arranged in a randomized complete block design with four replications, with three seedling ages as main plot, including (20, 30 and 40 days old) and four levels of potassium rates as sub plot with 0, 30, 60 and 90 kg K ha^{-1}. Clean seeds of genotype with a minimum of 95% germination rate were soaked in water for 24 h and incubated for another 24 h. Then, the pre-germinated seeds were sown in seedling trays filled with soil to produce uniform seedlings. Seeds were sown on 1 May 2009. Seedlings 20, 30 and 40 days old were transplanted in each hill and with a single plant per hill on

Table 1: Weather condition in experiment site in rice growth stage at Neka in 2009.

August	July	June	May	Variable
26.1	27.2	24.2	14.2	Minimum temperature
37.5	33.2	34.3	24.1	Maximum temperature
194.2	156.2	175.4	98.2	Evaporation(mm)
26.5	38.7	63.4	32.6	Total precipitation(mm)

Table 2: Selected soil properties for composite samples at experimental site in 2009.

Soil texture	K ppm	P ppm	N %	OC %	OM %	pH	EC µmohs/cm	Depth cm
Silt clay	185	9	0.32	1.72	2.46	7.32	0.91	0-30

30 May 2009. Total number of unit was 48 plots, the size of each plot being 5 m × 2 m. After transplanting, 5 cm water depth was maintained in the experimental plots. Ten days before harvest, the plots were drained to facilitate harvesting. Insects, diseases and weeds were intensively controlled to avoid any yield loss. Nitrogen and phosphorous fertilizers were used at the rates of 150 kg N ha^{-1} and 100 kg P_2O_5 ha^{-1} as urea and triple superphosphate as basal fertilizers were applied, respectively. Basal fertilizers were applied and incorporated in all plots 1 day before transplanting. Nitrogen was split-applied: 50 kg N ha^{-1} at basal, 50 kg N ha^{-1} at panicle initiation, 50 kg N ha^{-1} at full heading by hand broadcast method.

Twelve hills (0.48 m^2) were sampled diagonally from harvest area each plot at maturity to determine plant height, number of tiller per hill, number of effective tiller per hill, number of panicles per m^2, number of total spikelets per panicle and number of filled and blank spikelets per panicle. Plant height was measured from the plant base to the tip of the highest leaf (or panicle, whichever was longer) for all 12 hills in each plot. Panicles were hand-threshed and the filled spikelets were separated from blank spikelets by submerging them in tap water. Dry weight of rachis and filled and blank spikelets was determined after oven drying at 70°C to constant weight. Prior to harvest, the plants from 10 hills were obtained from each replication to measure yield components. Grain and biological yields and harvest index were determined from the 5 m^2 area in each plot and adjusted to the standard moisture content of 140 g H_2O kg^{-1}. Plants were separated into straw and panicles. Straw yield was determined after oven drying at 70°C to constant weight. Harvest index was calculated as the ratio of filled spikelets weight to aboveground biomass.

Lodging characteristic was observed when the flowering of the plant just started. Culm characters related to lodging were determined at 30 days after flowering. Three representative hills were sampled from each plot and the 12 largest tillers, 4 from each hill, were used to measure characters related to lodging. Culm height (length between plant base and panicle neck node) and the lengths of the third (N_3) and fourth (N_4) internodes from the top were measured. Fresh weight of the upper portion of the plant, including panicle and N_1 and N_2 with leaf and leaf sheath (W_1), was measured. The fresh weights of the third (W_2) and fourth (W_3) internodes with leaf sheath were also measured. Bending moment (BM) at N_3 or N_4 internode was calculated using the following formula [24].

BMN_3 = Length from the lowest node of N_3 to the top of panicle × (W_1+W_2),

BMN_4 = Length from the lower node of N_4 to the top of panicle × (W_1+W_2+W_3)

Then, bending moment was measured as culm length × plant fresh weight. Since stem lodging usually occurs at the lowest internodes [24], only the diameter of N_4 was measured near the lowest node of N_4 after removing the leaf sheath. Length was calculated for both N_3 and N_4. Plant stems diameter was measured with a slide caliper according to the method described previously [25]. Statistical analysis data of morphological traits were analyzed following analysis of variance (SAS) and means were compared based on Duncan multiple range test (DMRT) at the 0.05 probability level.

RESULTS AND DISCUSSION

Morphological Characteristics Related-lodging: It is seen from Table 3 that the plant height had not significant differences by the effect of the seeding ages and potassium rates, so the maximum and minimum plant height was from 30 and 20 day-old seedlings with 150.1 and 132.6 cm, respectively (Table 4). Consequently, increase of seedling age duo to decrease plant height. Table 4 shows that with increasing potassium rate from 0 to 90 Kg ha^{-1} plant height with the 7% have meaning

Table 3: Mean comparison of plant height and lodging-related morphological traits in seeding age and potassium rate of rice.

S.O.V	df	Plant height	Length of internode 3	Length of internode 4	Diameter of internode 3	Diameter of internode 4	Bending moment of internode 3	Bending moment of internode 4
Replication	3		6.22^{ns}	4.91^{ns}	0.27^{ns}	0.61^{ns}	27100.83^{ns}	34035.62^{ns}
Seedling age (S)	2		215.40**	86.69*	2.30**	3.38*	331331.74**	779123.89*
Error (a)	6		18.37	24.67	0.13	0.59	29497.78	74372.21
Potassium rate (K)	3		1.21^{ns}	2.47^{ns}	0.26^{ns}	0.20^{ns}	8158.83^{ns}	13856.15^{ns}
S×K	6		1.20^{ns}	12.70*	0.10^{ns}	0.14^{ns}	4166.82^{ns}	5984.38^{ns}
Error	27		2.04	3.80	0.13	0.28	9582.07^{ns}	17679.42
C.V. (%)	-		5.82	13.20	6.52	8.20	11.50	11.46

* Significant at $P\leq0.05$, ** Significant at $P\leq0.01$, ns, non significant.

Table 4: Mean comparison of plant height and lodging-related morphological traits in seeding age and potassium rate of rice.

S.O.V	Plant height cm	Length of internode 3 cm	Length of internode 4 cm	Diameter of internode 3 Mm	Diameter of internode 4 mm	Bending moment of internode 3 g.m^2	Bending moment of internode 4 g.m^2
Seedling age (Day)							
20		21.21 b	12.47 b	5.81 a	6.61 ab	699.90 b	921.90 b
30		24.01 b	12.68 ab	5.63 a	6.86 a	867.40 a	1202.00 a
40		28.49 a	17.12 a	5.08 b	5.97 b	986.40 a	1357.00 a
Potassium rate (Kg ha^{-1})							
0		24.29 a	14.57 a	5.44 ab	6.35 a	818.40 a	1129.00 a
30		24.64 a	14.25 a	5.71 a	6.65 a	860.10 a	1161.00 a
60		24.37 a	14.67 a	5.38 b	6.41 a	846.10 a	1145.00 a
90		24.99 a	15.35 a	5.51 ab	6.50 a	880.50 a	1207.00 a

Values within a column followed by same letter are not significantly different at DMRT (α= 0.05).

more increase. Table 3 shows that the length of third and fourth internodes was effected by the seeding age ($p\leq0.01$ and $p\leq0.05$, respectively), also seeding age had the significant effect on the diameter of third ($p\leq0.01$) and fourth ($p\leq0.05$) internodes. Potassium rates had not significant effect any on morphological characteristics related-lodging. The interaction effect of seeding age × potassium rates had the significant effect only on the length of fourth internodes ($p\leq0.05$). Islam *et al.* [24] found that morphologic traits related to lodging in hybrids and non hybrids varieties are different and diameter of fourth internode among genotypes from 14 mm to 26 mm, because this internode very important in decreasing lodging.

The longest third and fourth internodes were seen at 40 day-old seedlings (17.12 and 28.49 cm) and the shortest third and fourth internodes also seen at 20 day-old seedling which was 12.47 and 21.21 cm, respectively. So, third internode was taller than fourth internode (Table 4). The lowest and longest the diameters of third and fourth internodes were for 40 day-old seedling with 5.08 and 5.97 mm, respectively (Table 4). Table 4 shows that with increase of length of third and fourth internodes had decreased the diameter of third and forth internodes and increase seedling age had increased length of third and fourth internodes.

The longest diameter of third and forth internodes were potassium rate of 30 Kg ha^{-1} with 5.71 and 6.65 mm, respectively. High potassium rate due to more any increase diameter of third and forth internodes. Then, the longest of length of third and forth internodes were potassium rate of 90 Kg K ha^{-1} with 24.99 and 15.35 mm, respectively. While the minimum and maximum lengths of third and fourth internodes were for check 24.29 and 14.57 cm, respectively. Increase of potassium rate to 90 Kg K ha^{-1}, the length was increased and the diameter of these internodes had decreased. Therefore, the plant height by application of potassium rate increased. While the maximum and minimum diameter of third and fourth internodes were for check 5.44 and 6.35 mm, respectively.

Increase potassium rate from 0 to 90 Kg K ha^{-1} the diameter of fourth internode had ascending process, whereas the bending momentr changed from 1129 to 1207 g.cm. Among morphologic traits, third and fourth internodes with lodging had high and significant correlation, so breaking resistance and lodging index in internodes are important at inflection [26]. The maximum of length of fourth internode by the interaction effect of seeding age × potassium rate is for 40 day-old seedling with 90 Kg K ha^{-1} and the minimum of it is for 20 day-old seedling with 30 Kg K ha^{-1} that are 20.08 and 12.17 cm (Table 7). Morphologic traits related to lodging measured only for third and fourth internodes because the stem lodging usually happens in lower internodes [25].

Seeding age had significant effect on the bending moment of third ($p \leq 0.01$) and fourth ($p \leq 0.05$) internodes. Bending moment of the third and forth internodes with increase of seedling age from 20 days to 40 days had the ascending process. Also, the maximum and minimum bending moment of the third and forth internodes resulted for seedling age from 20 and 40 days with 699.90, 986.40 and 921.90 and 1357.0 g.cm, respectively. Potassium rate bending moment of the third and forth internodes from 0 and 90 Kg K ha^{-1} were 818.40, 880.50 and 1129.0 and 12.07 g.cm, respectively (Table 4). As a result, increase potassium rate and seedling age due to increase bending moment. Finally, the length of third internode had taller than the forth internode, but more bending moment. So, the fourth internode is important and sensitive to lodging because, increased lodging index. Islam *et al.* [24] reported that the length of stem has the positive correlation coefficient with the diameter of fourth internode, the length of first, second third and fourth internodes and also with the breaking resistance of third and fourth internodes but doesn't have the significant correlation with the dry weight, bending moment and lodging index of 3 and 4 nodes.

Yield Components: Panicle length had significant difference by the effect of the seeding ages, so the maximum and minimum panicle length was from 30 and 40 day-old seedlings with 26.16 and 23.78 cm, respectively (Table 6). Consequently, increase of seedling age duo to decrease of panicle length. Number of total tillers and number of effective tillers per plant was effected by the seeding age ($p<0.01$, $p<0.05$, respectively (Table 5). It is seen from Table 6 that the maximum number of total tillers per plant was from 20 day-old seedling with 14.88 tillers and the minimum of it were from 40 day-old seedling with 12.39 tillers. Number of effective tillers per plant was effected by potassium rate and was significant at $p<0.05$ and for 90 Kg K ha^{-1} 12.59 and for control 14.60 tillers were produced. But, number of total tiller per plant was not affected by potassium rate. Then, interaction effect of seeding age × potassium rate had significant difference on number of effective tiller per plant ($p<0.05$). The maximum number of total tillers per plant in interaction effect was for 20 day-old seedling with 30 Kg K ha^{-1} 16.1 tillers and the minimum of it was for 30 day-old seedling with control

Table 5: Mean squares of yield, yield components and harvest index in seeding age and potassium rate of rice.

S.O.V	df	Panicle length	Number of total tillers	Number of effective tillers	Number of panicles	Filled spikelets percentage	Grain yield	Straw yield	Biological yield	Harvest index
Replication	3	5.00^{ns}	21.07*	7.33^{ns}	7497.92^{ns}	4.20^{ns}	7458.97^{ns}	16039.67^{ns}	6757.99^{ns}	80.95^{ns}
Seedling age (S)	2	22.92*	30.12**	52.73*	39073.56**	51.40*	79076.26*	185345.88*	493292.29*	13.70^{ns}
Error (a)	6	3.13	2.22	8.69	3105.40	4.97	15528.16	26426.23	70059.94	28.88
Potassium rate (K)	3	1.15^{ns}	9.49*	0.33^{ns}	3089.64^{ns}	5.80^{ns}	3634.45^{ns}	9650.44^{ns}	21529.54^{ns}	3.01^{ns}
S×K	6	0.23^{ns}	5.58^{ns}	2.20*	1982.95^{ns}	2.23^{ns}	9129.52^{ns}	29330.44^{ns}	60523.16^{ns}	17.26*
Error	27	1.67	3.67	0.70	2112.13	3.33	4637.71	16927.61	35706.40	6.34
C.V. (%)	-	5.17	14.41	6.53	13.95	1.90	15.30	17.26	15.78	6.78

* Significant at $P \leq 0.05$, ** Significant at $P \leq 0.01$, ns, non significant.

Table 6: Mean squares of yield, yield components and harvest index in seeding age and potassium rate of rice.

Treatments	Panicle length cm	Number of total tillers per hill	Number of effective tillers per plant	Number of panicles per m^2	Filled spikelets percentage %	Grain yield g.m^2	Straw yield g.m^2	Biological yield g.m^2	Harvest index %
Seedling age (Day)									
20	25.12 ab	14.88 a	14.83 a	303.20 b	94.82 b	380.30 b	635.80 b	1016.00 b	37.34 a
30	26.16 a	12.63 b	11.39 b	298.60 b	98.19 a	519.80 a	846.90 a	1367.00 a	38.00 a
40	23.78 b	12.39 b	12.10	386.40 a	95.43 b	434.90 ab	778.10 a	1209.00 ab	36.17 a
Potassium rate (Kg ha^{-1})									
0	25.16 a	14.60 a	12.74 a	309.50 a	95.54 a	443.80 a	757.70 a	1201.00 a	36.97 a
30	24.72 a	12.98 ab	12.84 a	324.80 a	97.11 a	422.50 a	714.30 a	1137.00 a	36.77 a
60	25.39 a	13.03 ab	12.95 a	336.20 a	96.20 a	464.50 a	760.70 a	1220.00 a	37.90 a
90	24.81 a	12.59 b	12.56 a	347.00 a	95.75 a	449.30 a	781.80 a	1232.00 a	37.04 a

Values within a column followed by same letter are not significantly different at DMRT (α= 0.05).

Table 7: Interaction effect of traits in seedling age and potassium rate of rice.

S×K	Length of internode 4 cm	Number of effective tillers per plant	Harvest index %
S_1K_1	13.00 de	15.23 a	35.42 ab
S_1K_2	12.17 e	15.50 a	36.39 ab
S_1K_3	12.31 e	15.14 a	37.94 a
S_1K_4	12.37 e	13.45 b	39.63 a
S_2K_1	13.89 cde	10.81 d	37.92 a
S_2K_2	16.15 bcd	11.39 cd	36.28 ab
S_2K_3	15.09 bcde	11.68 cd	39.60 a
S_2K_4	13.60 cde	11.68 cd	38.19 a
S_3K_1	17.36 ab	12.18 bc	37.56 a
S_3K_2	14.42 bcde	11.62 cd	37.65 a
S_3K_3	16.61 bc	12.04 cd	36.17 ab
S_3K_4	20.08 a	12.55 bc	33.31 b

Values within a column followed by same letter are not significantly different according to DMRT.

10.81 tillers (Table 7). Increase seeding age and potassium rate had decreased the number of total tiller and the number of effective tiller per plant. While, number of panicles per square meter was statistically significant difference ($p<0.01$). It is obvious from Table 5 that number of panicle per square meter is affected by the seeding age ($P=0.01$), so the minimum number of panicles was for 30 day-old seedling with 298 panicle and the maximum was for 40 day-old seedling was 386 panicle per square meter.

Panicle numbers with increasing potassium rate was increased from 324 until 347 panicles with increasing potassium rate to 30 from 90 Kg K ha^{-1} and had the ascending process, while, panicle numbers was for check 309 panicle (Table 6). Also, the panicle numbers with the increase of potassium rate from 30 to 90 Kg K ha^{-1} had the ascending process, but there was not statistically significant difference. Mobasser *et al.* [27] found that in different genotypes of rice increase of stem numbers per plant, the number of panicles per m^2 increased. The filled spikelets percentage with the effect of seeding age shows the significant difference ($P=0.05$) (Table 5). The minimum of filled spikelets percentage was for 30 day-old seedling which frequently are 98.19 % and the maximum filled spikelet percentage was 20 day-old seedling (94.82 %) and according to the statistically this trait was not affected by the potassium rate because this trait related to grain filling period and current assimilations. The minimum filled spikelets percentage was for check which frequently 95.54 %.

Yield: The seeding age had significant difference on grain, straw and biological yields ($p\leq0.05$) (Table 5), so the lowest and highest grain yield was for 20 and 30 day-old seedling with 380.30 and 519.8 $g.m^2$, respectively. There was no significant difference in potassium rates. There was significant different interaction effect seeding age × potassium rate on harvest index ($p\leq0.05$) (Table 5). The highest harvest index was for 20 day-old seedling with 90 Kg K ha^{-1} (39.63 %) and the lowest was for 40 day-old seedling with 90 Kg K ha^{-1} with 33.31 % (Table 7). As, Table 5 shown that grain, straw and biological yields had increased by high potassium rates, but there was not significant. Increasing of seeding age duo to decreasing grain yield and harvest index. In fact, this difference result in every region indicated that grain yield was related to weather condition, sowing date, plant density and location conditions and management of fertilizers. Therefore, we founded that this result confirm by Kewat *et al.* [28] that how the mortality of young seedlings (14 days) right after transplanting was reported as a reason for the lower yield compared to that with older seedlings (28 days). Also, Khatun *et al.* [4] indicated that use of 45-day-old seedlings proved to be better than those aged 30, 60 and 75 days.

CONCLUSION

It must be mentioned in results the length of first, second and third especially fourth internodes were very important for sensitive to lodging. The length of internodes and diameter was correlate in lodging because relation between plant height and panicle length (weight) affect on lodging. So, for these reasons, it seems that potassium duo to decrease breaking resistance of third and fourth internodes. The least lodging of third and fourth result in high grain yield because this case makes the better and easier transfer of photosynthesis materials to grains (sink) and in result the least blank spikelet and the most panicle number in square meter. Also, we saw that the most grain yield was 30 days old seedling because the highest plant height and in result the maximum biological yield and harvest index was produced.

The longer stem length in rice may have the important role at increase of bending moment and the consequent of that at increase of lodging index but duo to more leaf area index for assimilate and sources for grain filling period. Increase of seedling age changed significantly number of panicle but increased blank spikelets. According to the results in this study, with the increase or decrease of seedling age, the number of total and effective tillers per plant decreased but the grain and biological yield had not increased significantly. So, the length of panicle had ascending process but the number of spikelets per panicle, the number of blank spikelets per panicle and 1000-grain weight and also with application of potassium rate straw yield didn't show the significant difference. In rice plant, because of the limitation of nutrition material absorption, increase of potassium rate result in bending moment of third and fourth internodes had the least. Although, potassium rate doesn't have the significant difference on the length of fourth internode and bending moment in the length of third and fourth internodes, but increase breaking resistance in third and fourth internodes and remobilization and translocation assimilate had decreased. Thus, potassium application attributed to uptake and transport of potassium to plant, although potassium application increase bending moment, but duo to decrease of lodging index because increases breaking resistance. Also, potassium application increase grain yield.

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