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Effect of Fertilization and Planting Density on the Yield of Two Varieties of Fine Rice

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Abstract: The effect of fertilization and planting density was determined on the yield of two varieties of fine rice cv. Kalizira and Badshabhog. Three different planting densities namely, 15cm x 10cm, 20cm x 12cm and 25cm x 15cm and four doses of fertilizer combination (N- P- K- S- Zn) namely 0-0-0-0-0, 20-15-11.25-7.5-1.25, 40-30-22.5-15-2.5 and 80-60-45-30-5 kg ha^{-1} were applied. Badshabhog was found significantly superior to Kalizira for number of grains panicle^{-1},1000- grains weight, grain yield and harvest index. Both the varieties performed best at 20cm x 12cm spacing and both of them also showed the highest response at 40-30-22.5-15-2.5 kg ha $^{-1}$ N- P- K- S- Zn. There was consistently significant increase in grain yields up to 40-30-22.5-15-2.5 kg ha $^{-1}$ N- P- K- S- Zn, beyond which the yields of both the varieties declined.

Key words: Fine rice, fertilization, planting density, yield

Introduction

A number of fine rice varieties are known to be grown by the farmers in Bangladesh. Bangladesh has a bright prospect for export of these fine rice thereby can earn foreign exchange. The yield of fine rice is very low in Bangladesh comparing to that of other countries. The reasons for such low yield are mainly associated with cultural technologies.

Among the cultural technology application of fertilizer and planting density are the important ones. Improper use of fertilizer may reduce the yield of rice. The efficient fertilizer management increased crop yield and reduces fertilizer cost. It is necessary to find the optimum rate of NPKS and Zn fertilizers for those elements by the rice plants for maximum yield and performance. The growth of rice plant is greatly affected both qualitatively and quantitatively by planting density. Planting density affects the normal physiological activities of the rice plants (UPCA and IRRI, 1967). On the contrary, optimum-planting density enables the plant to grow properly both in its aerial and underground parts by utilizing maximum radiant energy, nutrients, space and water, which ultimately lead to excellent crop production (Mian *et al.*, 1966). In dense populated rice fields the inter specific competition between the plants is high which sometimes results in lodging and favours the increased production of straw instead of grains (Matsuo, 1965).

For maximizing yield, manipulation of cultural technologies like planting density and fertilization are, therefore, essential. Selection of suitable planting density and optimum fertilizer combination are the most important factors for maximizing rice production. For fine rice the information is limited on planting density and fertilizer combination. This needs extensive search for finding interacting behaviour of variety of fine rice, planting density and rate of combination of fertilizers commonly used for supplementation.

A study was therefore, undertaken with planting density and level of fertilizer combinations to exploit the yield potential of two popular varieties of fine rice namely Kalizira and Badshabhog.

Materials and Methods

The experiment was conducted at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh during the period from July to December, 1998 in order to find the effect of planting density and N- P-K- S- Zn combination on yield of two varieties of fine rice. The experiment included three planting densities, such as 10cm x 15cm(D_1), 20cm x 12 cm (D_2) and 25cm x 15cm (D_3) and four fertilizer combinations viz. 0-0-0-0-0 (F_0), 20-15-11.25-7.5-1.25 (F_1), 40-30-22.5-15-2.5 (F_2) and 80-60-45-30-5 (F_3) kg ha^{-1} and two varieties of fine rice namely Kalizira and Badshabhog.

The experiment was laid out in split- plot design with three replications. The unit plot size was 10m^2 . Variety was given in main plot while planting density and fertilizer combination was given in split plot. All management practices were done in proper time starting from land preparation to crop harvest. The initial soil sample was tested chemically to assess the physiochemical properties. Five hills (excluding border hills) were randomly selected from each unit plot prior to harvest for recording different growth, yield and other crop characters. Entire plot was harvested for taking grain yield and straw yield data. Tiller number was recorded at 20- days interval from 20 to 100 DAT. Plant height at harvest, tiller number (total, bearing and non bearing spikelets number, sterility percentage, 1000- grains weight, grain yield, straw yield, biological yield and harvest index were recorded. The collected data were analyzed and the mean differences were adjudged by the Duncan's Multiple Range Test (Steel and Torrie, 1980) using statistical computer pakage (MSTAT).

Results and Discussion

Varietal performance: Variety differed significantly in number of grains panicle^{-1} thousand-grains weight, grain yield and harvest index (Table 1). Between the studied cultivars higher number of grains panicle^{-1} (103.58) was observed in Badshabhog. The weight of 1000- grains was higher in Badshabhog (10.76 g) than Kalizira (10.3 g). Similarly the grain yield was higher in Badshabhog (2.58 t ha^{-1}) than Kalizira (2.44 t ha^{-1}) due to the production of higher number of grains panicle^{-1} and higher weight of thousand grains. Harvest index (%) was maximum in Badshabhog (34.59). It can be concluded that Badshabhog outyielded the Kalizira due to its some superior yield characteristics like number of grain panicle^{-1}and 1000- grains weight. Kalizira on the other hand had superior quality of finer grains than Badshabhog.

Effect of fertilizer combination: The effect of the fertilizer combination on the yield and other crop characters of fine rice are presented in Table 2. The most of the yield contributing characters are influenced significantly by fertilizer treatment. Bearing tillers were increased compared to control. The highest number of tillers (7.58) were produced in F_3, which was statistically similar to F_2. Grains panicle^{-1} was also influenced by the fertilizer combination. The highest grains panicle^{-1} (112.3) was obtained in F_2 and F_1. The grains panicle^{-1} was also increased up to F_2 over the control. These results are almost in accord with the findings of Behera (1998). He found that 60 kg ha^{-1} N produced the highest grains panicle^{-1}. After F_2 treatment grains panicle^{-1} decreased due to excessive vegetative growth. The total number of spikelets panicle^{-1} was also influenced by fertilizer.The highest spikelets (132.0) panicle^{-1} and the lowest total spikelets (110.6) panicle^{-1} were found in F_2 and control, respectively and decreased after wards due to excess vegetative growth. Thousand gains weight followed the similar trend like total spikelets panicle^{-1}.

Table 1: Effect of variety on yield and crop characters of fine rice

Variety	Total tillers hill^{-1} (No.)	Bearing tillers hill^{-1} (No.)	Grains panicle^{-1} (No.)	Total spikelets panicle^{-1} (No.)	1000-grains weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (t ha^{-1})
Kalizira	8.29	7.28	94.94b	116.33	10.30b	2.44b	5.87	8.31	30.07b
Badshabhog	7.77	6.72	103.58a	121.30	10.76a	2.58a	4.94	7.52	34.59a
CV %	9.62	10.46	1.97	7.04	0.30	3.78	18.39	13.32	8.88
S$\bar{x}$	0.1288	0.122	0.3267	1.394	0.0037	0.0158	0.1656	0.1757	0.4782
Level of significance	NS	NS	0.01	NS	0.05	0.01	NS	NS	0.05

In a column figures having similar letter(s) do not differ significantly whereas figure having dissimilar letters differ significantly as per DMRT

Table 2: Effect of fertilizer combination on yield and crop characters of fine rice

Fertilizer combinitions	Total tillers hill^{-1} (No.)	Bearing tillers hill^{-1} (No.)	Grains panicle^{-1}	Total spikelets panicle^{-1}	1000-grains weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (t ha^{-1})
(0-0-0-0-0) (F_0)	7.44c	6.36b	92.17c	110.6c	10.28c	2.08c	3.95c	6.03d	34.59a
(20-15-11.25-7.5-1.25) (F_1)	7.85bc	6.93ab	102.3b	120.9b	10.65b	2.68b	5.72b	8.40b	32.46b
(40-30-22.50-15-2.5) (F_2)	8.23ab	7.13ab	112.3a	132.0a	10.90a	3.10a	6.70a	9.80a	31.87b
(80-60-45-30-5) (F_3)	8.60a	7.58a	90.29c	111.7c	10.28c	2.18c	5.23b	7.41c	30.39b
CV %	13.02	13.87	2.19	4.45	0.44	4.97	12.04	8.77	6.98
S$\bar{x}$	0.2464	0.2289	0.5125	1.245	0.0105	0.0298	0.1533	0.1635	0.532
Level of significance	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letters differ significantly as per DMRT

Table 3: Effect of planting density on yield and crop characters of fine rice

Planting density	Total tillers hill^{-1} (No.)	Bearing tillers hill^{-1} (No.)	Grains panicle^{-1}	Total spikelets panicle^{-1}	1000-grains weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (t ha^{-1})
(15cmx 10cm) D_1	5.81c	5.13c	93.19c	111.3c	10.65b	2.5b	5.56a	8.059b	32.10b
(20cmx 12cm) D_2	7.71b	6.64b	97.09b	116.8d	10.61a	2.69a	5.98a	8.67a	31.41b
(25cmx 15cm) D_3	10.57a	9.23a	107.5a	128.3a	10.40c	2.34c	4.67b	7.00c	33.42a
CV %	13.02	13.87	2.19	4.45	0.44	4.97	12.04	8.77	6.98
S$\bar{x}$	0.2134	0.1982	0.4438	1.079	0.0091	0.0258	0.1328	0.1416	0.4608
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letters differ significantly as per DMRT

Table 4: Effect of variety and planting density on yield and crop characters of fine rice

Variety x Planting density	Total tillers hill^{-1} (No.)	Bearing tillers hill^{-1} (No.)	Grains panicle^{-1}	Total spikelets panicle^{-1}	1000-grains weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (t ha^{-1})
Kalizirax (15cmx 10cm)	5.9	5.3	87.40d	108.7c	10.24e	2.433	6.253a	8.686ab	29.138
Kalizirax (20cmx 12cm)	7.91	6.78	87.64d	109.7c	10.42d	2.63	6.47a	9.10a	29.32
Kalizirax (25cmx 15cm)	11.06	9.75	109.8a	130.6a	10.23e	2.25	4.86c	7.12c	31.75
Badshabhogx (15cmx 10cm)	5.72	4.96	98.97c	113.9c	10.88a	2.56	4.86c	7.43c	35.05
Badshabhogx (20cmx 12cm)	7.5	6.5	106.5b	123.9b	10.81b	2.75	5.48b	8.23b	33.61
Badshabhogx (25cmx 15cm)	10.06	8.7	105.3b	126.1ab	10.58c	2.41	4.46c	6.88c	35.08
CV %	13.02	13.87	2.19	4.45	0.44	4.97	12.04	8.77	6.98
S$\bar{x}$	0.302	0.2803	0.6276	1.525	0.0129	0.036	0.1877	0.2	0.6516
Level of significance	NS	NS	0.05	0.01	0.01	NS	0.05	0.05	NS

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letters differ significantly as per DMRT

Table 5: Effect of variety and fertilizer combination on yield and crop characters of fine rice

Interaction (Variety x fertilizer combination)	Total tillers hill^{-1} (No.)	Bearing tillers hill^{-1} (No.)	Grains panicle^{-1}	Total spikelets panicle^{-1}	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (t ha^{-1})
Kalizirax (0-0-0-0-0)	7.80	6.82	87.42	107.0b	10.11f	2.00	3.89d	5.89d	34.06a
Kalizirax (20-15-11.25-7.5-1.25)	7.93	7.02	97.67	114.2b	10.41e	2.60	6.43ab	9.04b	29.13b
Kalizirax (40-30-22.50-15-2.5)	8.62	7.60	109.16	132.1a	10.58c	3.03	7.15a	10.19a	29.91b
Kalizira x (80-60-45-30-5)	8.82	7.66	85.51	112.0b	10.07f	2.11	5.97b	8.08c	27.15b
Badshabhogx (0-0-0-0-0)	7.08	5.88	96.91	114.2b	10.44e	2.16	4.01d	6.17d	35.11a
Badshabhogx (20-15-11.25-7.5-1.25)	7.76	6.84	106.98	127.7a	10.88b	2.74	5.01c	7.75c	35.78a
Badshabhogx (40-30-22.50-15-2.5)	7.83	6.66	115.37	131.9a	11.21a	3.15	6.24b	9.40ab	33.81a
Badshabhogx (80-60-45-30-5)	8.37	7.48	95.08	111.4b	10.50d	2.25	4.48cd	6.74d	33.62a
CV %	13.02	13.87	2.19	4.45	0.44	4.97	12.04	8.77	6.98
S$\bar{x}$	0.3485	0.3236	0.7247	1.761	0.0149	0.0416	0.2168	0.2312	0.7524
Level of significance	NS	NS	NS	0.01	0.01	NS	0.01	0.01	0.01

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Grains yield, biological yield and straw yield also followed similar trend but the biological yield and harvest index followed a different trend. The highest grain yield (3.10 t ha^{-1}) was achieved in F_2 and the lowest grain yield (2.08 t ha^{-1}) in control which was statistically similar to F_3. After F_2, yield was decreased due to lodging at flowering stage and the excessive N application before panicle initiation. Kabeerathumman *et al.* (1977) got almost the same results. They noted that paddy yield increased with the addition of 10 kg $ZnSO_4$ ha^{-1} along with 55 kg N ha^{-1} but the difference was not significant for further increase in N and Zn. The highest straw yield (6.7t ha^{-1}) was also produced in F_2 and lowest in control. Purohit *et al.* (1988) got almost the similar

Table 6: Effect of variety planting density and fertilizer combination on yield and crop characters of fine rice

Interaction(Variety x planting density x fertilizer)	Total tillers hill^{-1} (No.)	Bearing tillers hill^{-1}	Grains panicle^{-1} (No.)	Total spikelets Panicle^{-1} (No.)	1000-grains weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Kalizirax (15cmx 10cm)x (0-0-0-0-0)	5.93hij	5.33	76.32l	96.97kl	10.15k	1.99ij	3.47f
Kalizirax (15cmx 10cm)x (20-15-11.25-7.5-1.25)	5.86ij	5.33	92.92fgh	110.5hij	10.30ij	2.65ef	7.35ab
Kalizirax (15cmx 10cm)x (40-30-22.50-15-2.5)	5.40ij	5.00	97.70def	118.7e-h	10.49fg	2.98bcd	7.07ab
Kalizirax (15cmx 10cm) x (80-60-45-30-5)	6.40g-f	5.53	82.67jk	108.8h-l	10.01l	2.10hij	7.11ab
Kalizirax (20cmx 12cm)x (0-0-0-0-0)	6.8f-i	5.93	77.29l	96.32l	10.17k	2.15g-j	4.33f
Kalizirax (20cmx 12cm)x (20-15-11.25-7.5-1.25)	7.2e-i	6.20	85.41ij	103.0i-l	10.53f	2.76de	6.79ab
Kalizirax (20cmx 12cm)x (40-30-22.50-15-2.5)	9.00b-e	7.66	109.4c	137.3a-d	10.75de	3.22ab	8.12a
Kalizirax (20cmx 12cm)x (80-60-45-30-5)	8.66c-f	7.33	78.44kl	102.3jkl	10.22jk	2.39fgh	6.64abc
Kalizirax (25cmx 15cm)x (0-0-0-0-0)	10.66ab	9.20	108.7c	127.8a-g	10.02l	1.86j	3.86f
Kalizirax (25cmx 15cm)x (20-15-11.25-7.5-1.25)	10.73ab	9.53	114.7b	129.0a-g	10.41gh	2.41fgh	5.15c-f
Kalizirax (25cmx 15cm)x (40-30-22.50-15-2.5)	11.46a	10.13	120.3a	140.5a	10.51fg	2.91cde	6.28b-e
Kalizirax (25cmx 15cm)x (80-60-45-30-5)	11.40a	10.13	95.42efg	124.9d-g	9.97l	1.84j	4.16f
Badshabhogx (15cmx 10cm)x (0-0-0-0-0)	4.60j	4.06	92.31gh	109.6h-k	10.54f	2.18ghi	4.09f
Badshabhogx (15cmx 10cm)x (20-15-11.25-7.5-1.25)	5.60ij	4.66	101.9d	116.9fgh	11.16c	2.79de	4.50f
Badshabhogx (15cmx 10cm)x (40-30-22.50-15-2.5)	5.96hij	5.13	113.3bc	125.7e-g	11.5a	3.16bc	6.93ab
Badshabhogx (15cmx 10cm) x (80-60-45-30-5)	6.73f-j	6.00	88.34hi	103.4i-l	10.33hi	2.13g-j	3.93f
Badshabhogx (20cmx 12cm)x (0-0-0-0-0)	7.93d-h	6.40	98.71de	115.0g-j	10.49fg	2.29ghi	3.97f
Badshabhogx (20cmx 12cm)x (20-15-11.25-7.5-1.25)	8.10d-g	7.06	110.6bc	127.2b-g	10.74de	3.00bcd	6.42bcd
Badshabhogx (20cmx 12cm)x (40-30-22.50-15-2.5)	7.06e-i	6.06	120.4a	138.5abc	11.37b	3.45a	6.78ab
Badshabhogx (20cmx 12cm)x (80-60-45-30-5)	6.93f-i	6.46	96.39efg	115.0g-j	10.65e	2.27ghi	4.75ef
Badshabhogx (25cmx 15cm)x (0-0-0-0-0)	8.73c-f	7.20	99.7de	118.0fgh	10.28ij	2.00ij	3.97f
Badshabhogx (25cmx 15cm)x (20-15-11.25-7.5-1.25)	9.60a-d	8.80	108.4c	139.2ab	10.75de	2.42fg	4.11f
Badshabhogx (25cmx 15cm)x (40-30-22.50-15-2.5)	10.46abc	8.80	112.4bc	131.5a-e	10.77d	2.86cde	5.01def
Badshabhogx (25cmx 15cm)x (80-60-45-30-5)	11.46a	10.00	100.5de	115.8f-i	10.51fg	2.36fgh	4.77ef
CV %	13.02	13.87	2.19	4.45	0.44	4.97	12.04
$S\bar{x}$	0.603	0.56	1.255	3.051	0.0258	0.0721	0.3754
Level of significance	0.05	NS	0.01	0.01	0.01	0.01	0.01

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results that grain and straw yield increased up to 60 kg N ha^{-1} but further increase in N level did not increase the yield of high yielding varieties of rice significantly. Dwivedi (1995) got almost the similar results. Application of 60 kg N ha^{-1} might be considered as optimum for obtaining higher grain yields in Basmati type varieties (Rao *et al.*, 1993). The higher straw yield in higher doses of fertilizer combination was mainly caused due to increased number of total tillers hill^{-1}. The increased tiller production hill^{-1}and straw yield in rice due to increasing rates of nitrogen application have been reported by many authors (Sudhakar *et al.*, 1986 and Reddy 1986). Kumar *et al.* (1996) reported that 60 kg N ha^{-1} was the optimum rate for scented rice. Kalita *et al.* (1997) reported that grain yield increased with increasing fertilizer rates up to 40: 20 kg N: P_2O_5 ha^{-1}. The highest biological yield (9.8 t ha^{-1}) was found in F_2 over control and decreased afterwards due to same reason. But the highest harvest index was achieved at control.

Effect of planting density: Table 3 shows that almost all yield contributing characters were influenced significantly by planting density. Total tillers number was also influenced by planting density. The trend of total tillers increased with D_1 to D_3. Number of tillers was given double at D_3 (25cm x 15cm) comparing to D_1 (15cm x 10cm). Mian and Gaffer (1970) got almost the same results. They reported that in wide spacing the performance of individual hill was better with close spacing. Number of bearing tillers was double in D_3 comparing to D_1.

On the other hand, number of grains panicle^{-1} increased in the order of D_1, D_2 and D_3 (93.19, 97.09 and 107.5 respectively). Number of spikelets was non-significant. Thousand grains weight was also influenced by the planting density. The highest 1000-grains weight (10.61g) was also found in D_2 (20cm x 12cm) and the lowest (10.4g) was in D_3 (25cm x 15cm). The planting density at the same trend as observed in 1000-grains weight also influenced the grain yield. The highest grain yield (2.69 t ha^{-1}) was observed in D_2 that decreased afterwards. Mian and Gaffer (1970) reported exactly the same results. They observed that grain yield increased with increasing plant population up to a limit of 309868.91 plants ha^{-1} beyond which grain yield tended to decrease.

Straw yield was the highest in D_2, which was statistically similar to D_1. Venagopal and Singh (1985) reported that 15cm x 20cm spacing gave higher grain and straw yields than narrow spacing. The highest grain yield was also found in 20cm x 12cm. Trivedi and Kwatra (1985) got almost same results. They reported that 15cm x 15cm spacing produced the highest grain yield.

The highest biological yield (8.67 t ha^{-1}) was recorded in D_2 and the lowest was in D_3. Harvest index differed significantly. The highest harvest index (33.42%) was in D_3. The highest grain yield (2.69 t ha^{-1}) in D_2 was associated with individual grain weight (as expressed in terms of 1000-grains weight) number of bearing tillers hill^{-1}, number of grains panicle^{-1}, number of plants ha^{-1} at 20 cm x 12cm (D_2) spacing.

Interaction of variety and plating density: Effects of variety and planting density on yield and other crop characters of fine rice are presented in Table 4. Grains panicle^{-1} was influenced significant by this interaction. The highest number of grains (109.8) was observed in D_3 in the case of Kalizira and in Badshabhog (106.5) it was in D_2 (20cmx 12cm) which was similar to D_3. The lowest grains panicle^{-1} (87.40) was found in D_1 (15cmx 10cm) in Kalizira which was similar to D_2. In Badshabhog the lowest grain number (98.97) was found in D_1. Total spikelets panicle^{-1} was influenced significantly by this interaction, giving the highest number in Kalizira (130.6) and Badshabhog (126.1) both in D_3. The lowest total number of spikelets panicle^{-1} (108.7) was observed in D_1 of Kalizira, which was statistically similar to D_2. The lowest number of total spikelets panicle^{-1} (113.9) in case of Badshabhog was for D_1. An increasing trend of total spikelets panicle^{-1} was observed from D_2 and D_3 in both varieties. The highest 1000- grains weight (10.42 g) was observed in D_2 while the lowest (10.23 g) was in D_3 of Kalizira being statistically similar to D_1. Badshabhog produced the highest 1000-grains weight (10.88g) in D_1 and the lowest was in D_3(10.5 g). Grain yield was not significant due to interaction of variety and planting density. The highest straw yield (6.47t ha^{-1}) was found in D_2 in the case of Kalizira, which was statistically similar to D_1, and the lowest was in D_3 (4.86 t ha^{-1}). Similarly in Badshabhog, the highest straw yield (5.48 t ha^{-1}) was found in D_2 and the lowest (4.46 t ha^{-1}) in D_3 which was statistically at par with D_1. Islam *et al.* (1994) reported similar results. They reported that 20 cm x 15cm spacing produced 44% higher straw yield

than 40cm x 30cm spacing.

Interaction of variety and fertilizer combination: There was a significant interaction effect of variety and fertilizer combination on different crop characters (Table 5). Grains panicle^{-1} did not show significant difference due to interaction of variety and fertilizer combination. Total spikelets panicle^{-1} was influenced by the interaction. The highest number of total spikelets panicle^{-1} (132.1) was found in Kalizira with F_2 fertilizer combination while Badshabhog (131.9) gave the highest number of total spikelets in F_2 which was similar to F_1 .The lowest number of spikelets panicle^{-1} (107.0) was observed in control of Kalizira which was statistically similar to F_1 and F_3. Badshabhog produced the lowest total spikelets (111.4) in F_3 which was statistically similar to control (F_0). Thousand grains weight also differed significantly by interaction effect of variety and fertilizer combinations. The weight range of grains vary from 10.11 g in Kalizira with control to 11.21g in Badshabhog with F_2 fertilizer and the highest 1000-grains weight of Kalizira and Badshabhog were V_1F_2 (10.58 g) and V_2F_2 (11.21 g) respectively. The lowest 1000-grains weight (10.11 g) of Kalizira was found in F_3, which was similar to control while that of Badshabhog (10.44g) was in control. Grain yield was not significant due to the interaction effect of variety and fertilizer combination. Straw yield and biological yield were also influenced significantly by the interaction of variety and fertilizer combination. The highest straw yield (7.15 t ha^{-1}) and biological yield (10.19t ha^{-1}) were observed in V_1F_2 while the lowest straw yield (3.89t ha^{-1}) and biological yield (6.17t ha^{-1}) were observed in V_1F_0 and V_2F_0 respectively. Total spikelets panicle^{-1}, 1000-grains weight, straw yield and biological yield followed an increasing trend up to F_2 over the control and in decreased. The harvest index was also influenced significantly by this interaction. The highest harvest index was observed in F_1 (35.78%) of Badshabhog which was statistically similar to F_0, F_2 and F_3 The highest harvest index in case of Kalizira (34.06%) was for F_0.

Interaction of variety, planting density and fertilizer combination treatment: The interaction of variety, planting density and fertilizer combinations did not exert significant influence on bearing tillers hill^{-1}. There was a significant interaction effect of variety, planting density and fertilizer combination on the yield and other crop characters studied (Table 6). The highest total tillers hill^{-1} (11.46) was produced by Kalizira (V_1) at 25cm x 15cm (D_3) spacing and (F_2) 40-30-22.5-15-2.5kg ha^{-1} of N-P-K-S-Zn which was statistically followed by D_3F_0, D_3F_1 and D_3F_3. Badshabhog produced the highest number of tillers (11.46) in D_3F_3 which was statistically followed by D_3F_1 and D_3F_2. The highest grains panicle^{-1} (120.4) was found in$V_2D_2F_2$, which was similar to $V_1D_3F_2$ and the lowest grains number (76.32) was found in $V_1D_1F_0$ interaction, which was followed by $V_1D_2F_0$ and $V_1D_2F_3$. Panicle^{-1}. Badshabhog also gave the highest grains panicle^{-1} at 20cm x 12cm planting density and 40-22.5-15-7.5-2.5 kg ha^{-1} N-P-K-S-Zn fertilizer combination (Table 6). Kalizira gave the highest grain panicle^{-1} (120.3) at D_3F_2 which was statistically similar to $V_2D_2F_2$. In case of Kalizira (V_1) the highest total spikelets panicle^{-1} (140.5) was found in D_3F_2 and the lowest (96.32) in D_2F_0 while in Badshabhog (V_2) the highest total spikelets panicle^{-1} (139.2) was found in D_3 F_1 which was statistically similar to D_2F_2 and D_3F_2 and the lowest (103.4) was in D_1F_3. It was observed that all the total spikelets panicle^{-1} and grains panicle^{-1} exhibited a similar trend. Number of grains panicle^{-1} and total number of spikelets increased up to F_2 fertilizer combination over the control and with increasing fertilizer combination grains panicle^{-1} and total spikelets panicle^{-1} were increased. Thousand grains weight of Kalizira (V_1) and Badshabhog (V_2) was the highest in D_2F_2 and D_1F_2 (10.75 g and 11.5 g, respectively) and the lowest (10.01 g and 10.28 g, respectively) were found in D_1F_3 and D_3F_0. The lowest 1000-grains weight of Kalizira was similar in D_3F_0 and D_3F_3.

The lowest 1000-grains weight of Badshabhog was statistically similar to D_1F_3. Kalizira (V_1) gave the highest grain yield (3.22 t ha^{-1}) in D_2F_2 and the lowest (1.84 t ha^{-1}) was in D_3F_3 which was statistically similar to D_1F_0, D_1F_3, D_2F_0 and D_3F_0. Badshabhog (V_2) gave the highest yield (3.45 t ha^{-1}) in D_2F_2 and the lowest (2. 0 t ha^{-1}) was in D_3F_0 which was statistically at par with D_1F_0, D_1F_3, D_2F_0 and D_2F_3. The range of yield of Kalizira was 1.84 t ha^{-1} to 3.22 t ha^{-1} and that of Badshabhog was 2.00 t ha^{-1} to 3.45 t ha^{-1}. The straw yield exhibited mostly the similar trend like the grains yield. The highest straw yield (8.12 t ha^{-1}) of Kalizira (V_2) were in D_2F_2 and the lowest ones (3.47 t ha^{-1}) were in D_1F_0 while in Badshabhog (V_2) produced the highest straw yield (6.78 t ha^{-1}) in D_2F_2 and the lowest straw yield (3.93 t ha^{-1}) in D_1F_3. All the components of Kalizira and Badshabhog performed the best in V_2F_2.

It can be concluded that both Kalizira and Badshabhog gave the highest yield at 20cm x 12cm spacing with 40-22.5-15-7.5-2.5 kg N-P-K-S-Zn ha^{-1} fertilizer combination. The highest level of fertilizer combination and wide planting density resulted in the lowest yield due to sparse plant population and lodging of plants.

It may be concluded that both Kalizira and Badshabhog exhibited their best performance at 20 cm x 12 cm with 40-30-22.5-15-2.5 Kg ha^{-1} fertilizer combination.

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