AJA VOL (3) ISSUE 4, 2016: 86-89

Azarian Journal of Agriculture

www.azarianjournals.ir

Azarian Journals

Research article **ISSN:2383-4420**

Effect of planting geometry on yield and yield attributes of drought tolerant rice varieties in Nawalparasi, Nepal

Mohan Mahato[*1], Bishnu Bilas Adhikari[2], Keshav Raj Adhikari[3], Khem Raj Dahal[3]

Article Info

Accepted:
20 Aug. 2016

Keywords:
Drought tolerant rice varieties, Grain yield, Planting Geometry

ABSTRACT

A field experiment was conducted, to evaluate the yield and yield attributes of drought tolerant rice (*Oryza sativa* L.) varieties under different planting geometry in Narayani-7, Nawalparasi, Nepal from May to November, 2014. The experiment was carried out in two factor Randomized Complete Block Design with three replications consisting three rice varieties (Sukhadhan-4, Sukhadhan-5 and Radha-4) and four planting geometry (15 cm × 10 cm, 15 cm × 15 cm, 20 cm × 15 cm and 20 cm × 20 cm). The results revealed that the highest grain yield (6.5 t ha^{-1}) was obtained from planting geometry 20 cm ×15 cm with highest number of effective tillers m^{-2} (342.6) and highest harvest index (44.8%) while, number of filled grains $panicle^{-1}$ and panicle length was found statistically at par with 20 cm × 20 cm and 20 cm × 15 cm planting geometry. However, the straw yield and test weight were non-significant with different planting geometry. Regarding tested varieties, Sukhadhan-5 produced highest grain yield (6.1 t ha^{-1}) with highest number of effective tillers (337 m^{-2}), more number of filled grain $panicle^{-1}$ (144) and more harvest index (44%) compared to other tested varieties in the experiment. The Sukhadhan-4 recorded the longest panicle (28.5 cm) while Radha-4 produced significantly highest straw yield (8.1 t ha^{-1}). Thus, Sukhadhan-5 with planting geometry 20 cm × 15 cm found more economical and profitable to grow in rainfed lowland ecosystem in Terai and inner Terai areas of Nepal.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the important staple foods for nearly about seven billion people in the world. Approximately 163.2 million hectare area is covered with rice all over the world with an annual production of 719.7 million tones (FAOSTAT 2013). In Nepal, it is grown in about 1.48 million ha with the production of 5.04 million tons and productivity is 3.39ton ha^{-1} (MOAD 2014). About 21% (3.2 million hectares) of the total land area of Nepal is used for cultivation where the major crops are rice (45%), maize (20%), wheat (18%), millet (5%) and potatoes (3%), followed by sugarcane, jute, cotton, tea, barley, legumes, vegetables and fruits (Gautam 2008).

The projected climate changes also have considerable impact on agricultural production. It is estimated that the average temperature in Nepal is rising by 0.5°C per decade (Lama and Devkota 2009). The increased temperature with variable rainfall condition create periodic drought in rice growing season and sometime even changes cultivation land in to barren land. The uneven distribution of rainfall and shortage of water makes the drought varieties important (Luo and Zhang 2001). It is often unpredictable and does not occur in all years in a target environment and is becoming more severe as the human population increases and change in global climate. Drought stress during the vegetative growth, flowering and terminal stages of rice cultivation can cause spikelet sterility, which ultimately decreases the yield (Kamoshita et al2004). It is generally assumed that occurrence of drought and relatively low uses of chemical fertilizers are the major factors causing to low yields.

Planting density of a crop determines solar radiation interception, crop canopy coverage and

[1] Institute of Agriculture and Animal Science, Kirtipur, Nepal
[2] Institute of Agriculture and Animal Science, Lamjung, Nepal
[3] Institute of Agriculture and Animal Science, Rampur, Nepal

*Email: mahatomohan@yahoo.com

total dry matter accumulation (Anwar et al.2011). The competition among plants for light, water, and nutrients become severe, when hill spacing exceeds the optimum level. Consequently, the plant growth slows down and ultimately the grain yield decreases. The tillering habit and production of spikelets per panicle depends on the spacing of transplanting to a great extent, which is responsible for the variation of yield in rice per unit area. So the planting geometry and plant spacing should be optimized by keeping in mind different aspects of cropping management techniques. A dense population of crops may have limitations in the maximum availability of different factor like solar radiation, plant nutrients, availability of CO2 and moistures, it is, therefore, necessary to determine the optimum density of plants population per unit area for obtaining higher yields (Baloch et al 2002). Hence, aim of this study was to investigate the influence of different planting geometry on yield and yield attributes of drought tolerant rice varieties.

MATERIALS AND METHODS

The experiment was conducted in Narayani VDC, ward No. 7 of Nawalparasi district during May to November, 2014. Geographically, it is located at 27°35' N Latitude and 84°2' E Longitudes at the elevation of 254 m.a.s.l.. The average monthly minimum and maximum temperature were 20.43^{0}C and 35.87^{0}C respectively and the maximum rainfall was observed in the month of August (735 mm). The meteorological data for the growing season of crop during 2014 is presented in Table 1. Soil analysis results show that (Table 2), the soil was silt loam, pH 6.67 and low in organic matter (2.1%). The experiment consists of three drought tolerant rice varieties viz. Sukhadhan-4, Sukhadhan-5 and Radha-4 (check variety) and four planting geometry viz. 15 cm × 10 cm, 15 cm × 15 cm (check geometry), 20 cm × 15 cm and 20 cm × 20 cm.

The experiment was laid out in randomized complete block design (RCBD) consisting three replications. Each replication consists 12 plots and the unit plot was 9 m^2 (3 m × 3 m) with the total experimental area of 467.5 m^2. The individual plots and replication were separated by 0.5 m. Dry nursery bed was prepared for raising the seedlings

Table 1. meteorological data during crop growing season 2014

Months	Rain fall (mm)	Avg. maximum temp. (^{0}C)	Avg. minimum temp. (^{0}C)
June	510.80	35.87	25.76
July	652.60	33.75	25.61
August	735.30	33.40	25.24
September	248.00	33.59	24.32
October	122.00	31.19	20.43

Source: Department of Hydrology and meteorological station, 2014

and 20 days old seedlings are transplanted in puddled field in 15 cm × 10 cm, 15 cm × 15 cm, 20 cm × 15 cm and 20 cm × 20 cm planting geometry, each hill consisting single seedling. Fertilizer dose of 60:30:20 (N:P:K) was applied from urea (46%N), Di-ammoniumPhosphate (DAP) (18% N and 46% P_2O_5) and Murate of Potash (MOP) (60% K_2O). Half dose of Nitrogen and full dose of P and K were applied before final land preparation as basal dose and remaining dose of N was applied at panicle initiation stage.

After physiological maturity, data regarding number of effective tillers m^{-2}, number of grains panicle^{-1}, 1000 grain weight (g), grain yield and straw yield were recorded from unit plots. The crop was harvested at maturity from net plot. The grains and straws are sun dried and converted to t ha^{-1} with 14% moisture content of grains. The biological yield and harvest index were calculated by using the following formula.

Biological yield = Grain yield + straw yield

Harvest index = (grain yield/ biological yield) × 100

Collected data were analyzed statistically using R- program with Agricola, Least Significant Difference (LSD) and Duncan Multiple Range Test (DMRT), as mean separation technique was applied to identify the most efficient treatment (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Effect of planting geometry

Number of effective tiller m^{-2}, panicle length, number of grain panicle^{-1}, grain yield and harvest index were significantly affected by different planting geometry, whereas thousand grain weightand straw yield were not affected by the planting geometry (Table 3). The panicle lengths, number of grain panicle^{-1} were statistically par with the planting geometry 20 cm × 15 cm and 20 cm × 20 cm. whereas the lowest panicle length and number of grain panicle^{-1} were recorded in the closer spacing i.e. 15 cm × 10 cm. Similar type of result was also reported by Bozorgi et al. (2011) and Bezbaruha et al. (2011) who also found the longer panicle in wider spacing. The highest numbers of effective tiller m^{-2} (342.6), highest grain yield (6.5 t ha^{-1}) and harvest index (44.8%) were obtained from the planting geometry 20 cm × 15 cm while lowest effective tiller m^{-2} (275), grain yield (5 t ha^{-1}) and harvest index (39.2%) were recorded in the closer planting geometry i. e. 15 cm x 10 cm. The maximum grain yield and harvest index in planting geometry 20 cm × 15 cm is due to highest number of effective tiller m^{-2} .This result is also supported by Pokhrel et al.(2013), Verma et al.(2002), Rajesh and Thanunathan (2003) who were also found the maximum yield in planting

Table 2. Physico-chemical properties of the soil of the experimental site (2014)

S.N.	Properties	Content	Category
1	**Physical properties**		
	Sand (%)	21.6	
	Silt (%)	58.80	
	Clay (%)	19.60	
	Soil texture		Silt loam
2	**Chemical properties**		
	pH (1:2)	6.67	Slightly Acidic
	Total Nitrogen (%)	0.10	Medium
	Available Phosphorus (P_2O_5 Kg ha^{-1})	45	Medium
	Available Potassium (K_2O Kg ha^{-1})	190.78	Medium
	Organic matter (%)	2.1	Low

geometry 20 cm × 15 cm. Verma et al (2002) also found the highest harvest index in planting geometry20 cm × 15 cm over the other planting geometry.

Effect of varieties

The data of table 3 also show the significant difference among the varieties. Number of effective tiller m^{-2}, panicle length, number of grain per panicle, grain yield, straw yield and harvest index were significantly difference among the varieties used. Longest panicle (28.5 cm) was recorded in the sukhadhan-4 whereas Radha-4 and sukhadhan-5 recorded the statistically similar panicle length. Similarly, Sukhadhan-5 and Radha-4 recorded the statistically equal number of grains $panicle^{-1}$ whereas sukhadhan-4 recorded the lowest number of grain $panicle^{-1}$. Highest number of effective tiller m^{-2}, grain yield (6.1 t ha^{-1}) and harvest index (43.9%) (Table 3) were obtained from the Sukhadhan-5 where as Radha – 4 and Sukha dhan – 4 recorded the statistically similar effective tiller m^{-2}, and grain yield and this result is also supported by Yadaw (2014) who also reported the highest grain yield in Sukhadhan-5 than Sukhadhan-4 and Radha-4. Maximum straw yield (8.1 t ha^{-1}) was obtained from Radha-4 whereas Sukhadhan-4 and Sukhadhan-5 recorded the statistically similar straw yield.

Statistically the interaction between the planting geometry and varieties on grain yield observed non-significant However, among the treatment combination of varieties and planting geometry Sukhadhan-5 with plant spacing 20 cm × 15 cm (7 t ha^{-1}) produced the highest grain yield whereas Radha-4 with plant spacing 15 cm × 10 cm recorded the lowest grain yield (4.85 t ha^{-1}).

CONCLUSION

The planting geometry 20 cm × 15 cm shown the highest grain yield (6.5 t ha-1) and straw yield (7.9 t ha-1) compared to other planting geometry in rainfed low land condition. Regarding varieties, Sukha dhan – 5 produced highest grain yield (6.1 t ha-1), while Radha – 4 produced the highest straw yield (8.1 t ha-1). Therefore, we can have concluded that Sukha dhan – 5 with planting geometry 20 cm × 15 cm is recommended for rainfed loland and subtropical environment in order to get the maximum yield per unit area.

Table 3. Effect of planting geometry on yield and yield attributes of drought tolerant rice varieties

Treatments	Effective tiller m^{-2}	Panicle length (cm)	Number of grain $panicle^{-1}$	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw (t ha^{-1})	HI (%)
Variety (A)							
Radha-4	291^b	28^b	142^a	27.7	5.4^b	8.1^a	40.1^c
Sukha dhan-5	337^a	28^b	144^a	28.1	6.1^a	7.8^b	43.9^a
Sukha dhan-4	302^b	28.5^a	138^b	27.8	5.5^b	7.6^b	41.8^b
LSD	13.36	0.35	4.06	NS	0.23	0.25	1.02
SEm±	4.55	0.12	1.38	0.19	0.08	0.08	0.34
Spacing (B)							
15 cm × 10 cm	275^d	26.6^c	127^c	28	5.0^d	7.8	39.2^d
15 cm × 15 cm	299.4^c	28^b	141^b	27.8	5.4^c	7.9	40.7^c
20 cm × 15 cm	342.6^a	29^a	147^a	27.6	6.5^a	7.9	44.8^a
20 cm × 20 cm	323.1^b	29.1^a	150^a	28.1	5.9^b	7.	43.0^b
LSD	15.4	0.4	4.69	NS	0.26	NS	1.18
SEm±	5.3	0.13	1.6	0.22	0.09	0.088	0.4
CV%	5.1	1.45	3.4	2.46	4.47	3.79	2.87
Mean	310.1	28.2	141.2	27.8	5.68	7.82	41.94

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Journal sponsorship

Azarian Journal of Agriculture is grateful to the ***University of Maragheh*** and its faculty members for their ongoing encouragement, support and assistance.