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Growth and yield response of direct seeded rice (*Oryza sativa* L.) to dates of sowing and varieties

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Abstract
A field experiment was carried out at Agricultural Research Station, Dhadesugur in Karnataka during 2018-19 to study on "Response of direct seeded rice (*Oryza sativa* L.) to dates of sowing and varieties". The experimental site was medium black clay soil belonging to the order *vertisol* with soil pH (8.10), EC (0.65 dS m^{-1}), available nitrogen (244.60 kg ha^{-1}), P_2O_5 (37.50 kg ha^{-1}) and K_2O (336.3 kg ha^{-1}). The experiment comprised of five dates of sowing *viz*., D_1: 2nd Fortnight of June, D_2: 1st Fortnight of July, D_3: 2nd Fortnight of July, D_4: 1st Fortnight of August and D_5: 2nd Fortnight of August and four varieties *viz*., V_1: GGV- 05- 01, V_2: RNR-15048, V_3: BPT-5204 and V_4: GNV-10-89. These treatments were laid out in split plot design with three replications. Data on growth and yield of each crop was recorded and statistically analyzed. The experimental results revealed that, 2nd fortnight of June is the best time of sowing for different parameters such as number of tillers per square meter (404.3), plant height (90.0 cm), leaf area index (1.74), total dry matter production (40.0 g), days to 50 per cent flowering (91.6 days), days to maturity (131.4 days), number of grains per panicle (273.8), panicle length (22.9 cm), 1000 grain weight (17.4 g), number of panicles per square meter (275.7), panicle weight (3.4 g), grain yield (6272 kg ha^{-1}) and straw yield (7516 kg ha^{-1}), whereas sowing on 2nd fortnight of August has given the lowest value for all the studied traits. GGV-05-01 rice variety surpassed other varieties for all the studied characters.

Keywords: Direct seeded rice (DSR), dates of sowing, varieties, yield

Introduction
Rice (*Oryza sativa* L.) is a major cereal crop that plays an important role in the national food security. It is a staple food and primary source of food for more than half of the world's population. About 90 per cent of the world's rice is produced and consumed in Asia and India ranks second in rice production after China. In India, rice is grown in an area of 42.9 million hectare with a production of 111.1 million tonnes and an average productivity of 2.58 tonnes per hectare (Anon., 2018) [2]. In Karnataka, rice is grown in an area of 1.36 million hectare with a production of 3.99 million tonnes and the productivity of 3.10 tonnes per hectare (Anon., 2018) [2]. Further, Tunga Bhadra Project (TBP) irrigation command earmarked for paddy cultivation, is witnessing tremendous increase in the area of paddy with 100 per cent cropping intensity particularly in Siruguppa, Sindhanur and Gangavati, lying in the upper reaches of the project with rice during both the seasons and hence, the command area is considered to be the "Rice Bowl of Karnataka" perhaps with highest productivity in the state.
In most of the Asian countries, rice is grown by manual transplanting of 21 days old seedlings into puddled soil. Puddling is achieved by intensive soil tillage under wet conditions. The puddling operation creates a hard pan below the plow layer and reduces soil permeability. However, this operation leads to higher losses of water through surface evaporation and percolation. Hence, in recent years, to overcome all these problems, many methods of rice cultivation have been developed *viz*., direct seeded rice (DSR), system of rice intensification (SRI) and aerobic method of rice cultivation. These are considered as systems rather as technologies, as they involve holistic management of resources to provide ideal growing condition for rice plant (Anon., 2002) [1].
DSR is considered as water saving technology which can help to overcome the present water scarcity and nutrient loss.

To make paddy cultivation cost effective and eco-friendly, direct-seeded rice provides an option which saves not only labour required for transplanting but also helps to preserve natural resources especially underground water. Time of sowing is one of the critical aspects of direct seeding of rice and determines the productivity of a crop. Optimum sowing time for a crop is location specific. Production of direct seeded rice decreases if there is delay in sowing. At a specific location, maximum grain yield can be achieved by sowing crop at the optimum time, which may vary from variety to variety (Reddy and Narayana, 1984) [16]. Rice varieties vary in their seedling vigor, weed competitiveness, submergence and drought tolerance, maturity duration, lodging resistance, affecting the resource utilization and productivity. Not much information is available on suitable varieties and crop establishment practices for direct seeding in comparison to traditional method. Therefore, it is essential to know the date of sowing and screen the rice varieties which are suitable for delayed sowing in direct seeded rice.

Material and Methods

A field experiment was carried out at Agriculture Research Station, Dhadesugur in Karnataka during 2018-19 to study on "Response of direct seeded rice (*oryza sativa* l.) to dates of sowing and varieties". The centre is located in agro-climatic zone III (Northern Dry zone) of Karnataka. The station is situated at latitude of 15° 69' N and 76° 89' E longitude with an altitude of 358 m above mean sea level. The experimental site was medium black clay soil belonging to the order *vertisol* with soil pH (8.10), EC (0.65 dS m^{-1}), available nitrogen (244.60 kg ha^{-1}), P_2O_5 (37.50 kg ha^{-1}) and K_2O (336.3 kg ha^{-1}). The experiment comprised of five dates of sowing *viz*., D_1: 2nd Fortnight of June, D_2: 1st Fortnight of July, D_3: 2nd Fortnight of July, D_4: 1st Fortnight of August and D_5: 2nd Fortnight of August and four varieties *viz*., V_1: GGV- 05- 01, V_2: RNR-15048, V_3: BPT-5204 and V_4: GNV-10-89. Crop was sown with the spacing of 20 cm between the rows in 6 x 4 m plot. As split-split plot design with three replications was used, dates of sowing were allocated to the main plots while rice varieties in the sub plots. These treatments were laid out in split plot design with three replications. The recommended dose of fertilizer to each crop was applied at the rate of 150:75:75 kg N, P_2O_5, K_2O ha^{-1} in the form of urea, diammonium phosphate and muriate of potash, respectively. Entire quantity of phosphorus, potassium and 50 per cent of nitrogen were applied at the time of sowing. Remaining 50 per cent of nitrogen was applied as two splits, one at tillering stage and other at panicle initiation (PI) stage. Farmyard manure at 5 tonnes per hectare was applied one week before sowing and incorporated into the soil before passing the cultivator. Data were collected on number of tillers per square meter, plant height, leaf area index, total dry matter production, days to 50 per cent flowering, days to maturity, number of grains per panicle, panicle length, 1000 grain weight, number of panicles per square meter, panicle weight, grain yield and straw yield. The statistical analysis for various characters under investigation was done.

Results and Discussion

The growth and yield parameters of direct seeded rice differed significantly as influenced by different varieties under varied dates of sowing. The data in Table 1 shows that growth parameters *viz.*, number of tillers per square meter, plant height, leaf area index and total dry matter production were recorded highest by the crop sown on 2nd Fortnight of June which was on par with the crop sown on 1st Fortnight of July. El-Hity *et al*. (1987) [10] found that number of days after sowing (D.A.S) up to panicle initiation (P.I), maximum tillering (M.T.), heading dates (H.D.) and grain yield (t ha^{-1}) were drastically reduced with delay of sowing. Higher plant height (90 cm) and number of tillers per square meter (404.3) is attributed to the reason that early sowing of crop had longer growing period due to photoperiodic response. This variability indicates the effect of environmental factors on different plant growth characters. These results were in conformity with the findings of Khakwani *et al*. (2006) [12] and Paraye and Kandalkar (1994) [15] who reported that plant height and tillers of cultivars were significantly affected by sowing dates. Due to better crop growth in early stages and production of comparatively more number of leaves per plant, higher LAI (1.74) was observed. Dileep *et al*. (2018) [9] states that, early planting had more LAI (2.42) than late planting (2.22). The DMA is generally proportional to leaf area index and number of tillers. El-Khoby (2004) [11] showed that delay in sowing date sharply decreased the leaf area index, dry matter production and chlorophyll content. Higher dry matter production (40 g $plant^{-1}$) may be due to more number of leaves, which inturn has high photosynthetic rate, thus increased amount of photosynthate accumulation which was provided by more availability of PAR, nutrient and soil moisture. This was in proximity with the findings of Pandey *et al*., 2001 [14] and Biswanath *et al*., 2016 [7]. Crop sown on 2nd Fortnight of June took less days to 50 per cent flowering and days to maturity. Generally, it seems that early sowing dates produce early flowering and maturity. On the other hand, late sowing dates produce late flowering and maturity. The data on days to fifty per cent flowering and days to maturity reflects the effect of temperature from high to low on early or delay flowering and maturity in rice, therefore this character can be considered as an indicator for the heat stress (effect) in rice flowering and maturity (Khalid *et al*., 2015) [13]. Akbar *et al*., 2010 [5] also reported that the crop was sown on 20th June (early sowing) took less days to reach 50 per cent flowering and maturity compared to other dates of sowing.

Table 1: Plant height (cm), number of tillers per square meter, leaf area index and dry matter production (g $plant^{-1}$) of direct seeded rice as influenced by different varieties under varied dates of sowing

(D) / (V)	Plant height (cm)					Mean	Number of tillers per square meter					Mean	Leaf area index					Mean	Dry matter production (g $plant^{-1}$)					Mean
	D_1	D_2	D_3	D_4	D_5		D_1	D_2	D_3	D_4	D_5		D_1	D_2	D_3	D_4	D_5		D_1	D_2	D_3	D_4	D_5	
V_1	97.6	94.7	90.9	85.5	80.9	89.9	417.3	405.0	397.3	386.0	372.3	395.6	2.04	1.72	1.59	1.44	1.25	1.61	44.7	41.5	38.5	36.1	34.1	39.0
V_2	88.4	85.1	84.0	79.5	74.4	82.3	400.7	385.0	376.3	363.3	351.0	375.3	1.66	1.48	1.27	1.17	1.05	1.33	38.3	35.8	34.1	32.0	30.3	34.1
V_3	80.9	77.4	74.1	72.5	67.1	74.4	391.0	377.0	366.0	354.0	340.0	365.6	1.48	1.35	1.20	1.08	0.84	1.19	35.5	33.3	31.4	29.6	27.5	31.4
V_4	93.1	89.2	87.8	84.5	81.7	87.3	408.0	395.7	388.3	376.3	364.3	386.5	1.79	1.63	1.45	1.25	1.11	1.44	41.4	39.2	37.4	35.2	33.1	37.2
Mean	90.0	86.6	84.2	80.5	76.0		404.3	390.7	382.0	369.9	356.9		1.74	1.55	1.38	1.23	1.06		40.0	37.4	35.4	33.2	31.3	
	SEm±		C.D (p=0.05)				SEm±			C.D (p=0.05)			SEm±			C.D (p=0.05)			SEm±			C.D (p=0.05)		
(D)	1.77		5.12				2.74			7.93			0.05			0.14			0.86			2.49		

(V)	1.12	3.23	3.20	9.24	0.06	0.18	0.75	2.18
(D X V)	1.44	NS	4.13	NS	0.08	NS	0.97	2.81

Note:

D: Dates of sowing
D_1: 2nd Fortnight of June
D_2: 1st Fortnight of July
D_3: 2nd Fortnight of July
D_4: 1st Fortnight of August
D_5: 2nd Fortnight of August

V: Varieties
V_1: GGV-05-01
V_2: RNR -15048
V_3: BPT -5204
V_4: GNV-10-89

Table 1a: Days to 50 per cent flowering and Days to maturity of direct seeded rice as influenced by different varieties under varied dates of sowing

(D) / (V)	Days to 50% flowering					Mean	Days to maturity					Mean
	D_1	D_2	D_3	D_4	D_5		D_1	D_2	D_3	D_4	D_5	
V_1	92.0	92.7	93.3	94.0	96.3	93.7	130.0	133.3	135.7	138.0	142.3	135.9
V_2	89.7	90.3	91.0	91.7	94.0	91.3	122.3	125.0	127.3	130.0	134.0	127.7
V_3	93.7	94.7	95.3	96.3	98.0	95.6	148.7	151.7	153.7	156.3	161.7	154.4
V_4	91.0	91.7	92.3	93.0	95.0	92.6	124.7	128.3	130.3	132.7	136.3	130.5
Mean	91.6	92.3	93.0	93.8	95.8		131.4	134.6	136.8	139.3	143.6	
	SEm±		C.D (p=0.05)				SEm±			C.D (p=0.05)		
(D)	0.50		1.44				0.87			2.52		
(V)	0.47		1.36				1.18			3.42		
(D X V)	0.61		NS				1.53			NS		

Note:

D: Dates of sowing
D_1: 2nd Fortnight of June
D_2: 1st Fortnight of July
D_3: 2nd Fortnight of July
D_4: 1st Fortnight of August
D_5: 2nd Fortnight of August

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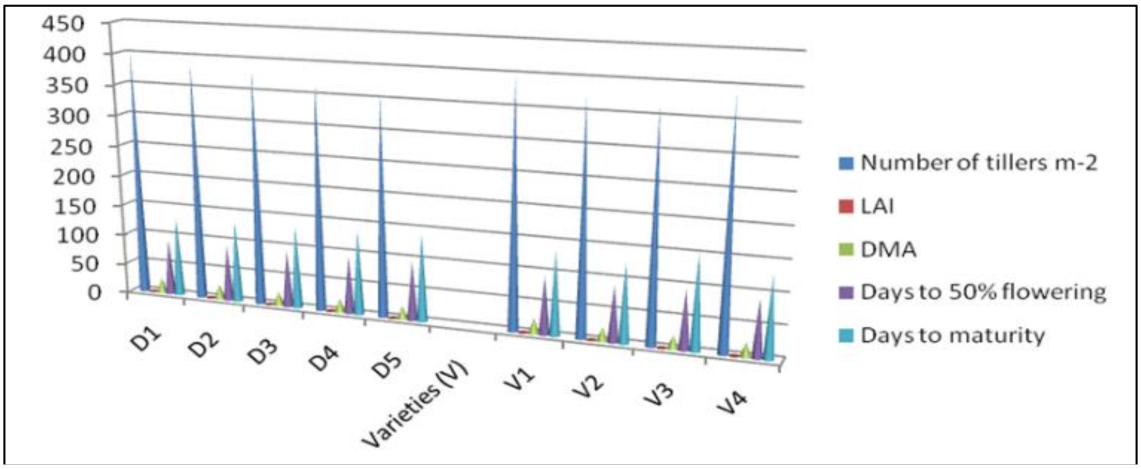

Fig 1: Different growth parameters at 90 DAS under varied dates of sowing and different varieties

The data in Table 1 showed that higher plant height (89.9 cm), number of tillers per square meter (395.6), leaf area index (1.61) and total dry matter production (39.0 g plant^{-1}) were recorded highest by the variety GGV-05-01. Difference in different plant growth parameters due to genotypes may be attributed to their inherent characteristics as they vary in their seedling vigour, drought tolerance, maturity duration and difference in the resource utilization productivity. Significant differences in plant growth characteristics of rice as influenced by various genotypes under aerobic conditions were also reported by Parashivamurthy *et al.* (2012) [19]. The increase in DMA can be attributed to a possible reduction in transpiration rate and normal gas exchange resulting in increased production of photosynthates and translocation to sink (Balaji *et al*., 2016) [14]. Whereas less days to 50 per cent flowering (91.3) and days to maturity (127.7) was observed in the variety RNR-15048 and this might be due to its short duration as compared to other varieties. Similar results were reported by Shubha (2016) [8] and Bashir *et al*. (2010) [5].

Crop sown on 2nd Fortnight of June recorded higher yield parameters of direct seeded rice *viz*., number of panicles per square meter, panicle length, panicle weight and total grains per panicle which was on par with crop sown on 1st Fortnight of July (Table 2). Test weight, grain yield and straw yield are presented in the Table 2a. Sharief *et al.* (2000) [17] found that early sowing dates (May 10 th) had marked effect on number of panicles m^{-2}, number of filled grains per panicle, 1000 grain weight, grain and straw yields fed^{-1}. More number of tillers per square meter might be the reason for more number of panicles per meter square (275.7) by the crop sown on 2nd Fortnight of June. Similar result was recorded by Dileep *et al*., 2018 [9], where early sown crop registered more number of panicles than the crop sown later. Early sowing recorded higher panicle length (22.9 cm) and panicle weight (3.4 g). The plant height is responsible for interception of solar radiation in rice canopy and increase in panicle length. Since there was higher panicle length, more number of filled grains and also better translocation of photosynthates in the crop sown on 2^{nd} fortnight of June, thus higher panicle weight was observed. Shortage of assimilate supply due to inhibition of photosynthetic processes is one of the major factors determining grain filling. Similar effect was found by Bheru *et al*., 2016. Higher test weight by crop sown on 2^{nd} fortnight of June (17.6 g) might be due to better translocation of photosynthates and bolder seeds. Higher 1000-grain weight might be ascribed to less competition among productive tillers, more filling of starch in grains and better kernel development (Asif *et al*., 2014) [3]. Fertility of spikelets and development of grains depend on environmental factors such as nutrients, moisture and light.

From previous studies, however, it is doubtful that assimilate supply to the grain during the early grain filling period alone defines potential grain growth and determines final grain weight. If assimilate supply to rice is restricted by shading or unfavorable cultivated conditions in the first 10 days of the grain filling period, the grain may be profoundly affected, as grain growth rate is generally highest within 2 weeks after heading. Early planting produced more number of total grains (273.8) per panicle than late planting. This showed that number of filled grains per panicle gradually decreases with the delayed sowing (Dileep *et al*., 2018) [9]. As higher growth and yield attributes was attained by the crop sown on 2^{nd} fortnight of June, there was a higher grain and straw yield (6272 and 7516 kg ha^{-1}, respectively). Higher yield of DSR sown early might be due to better utilization of heat units during whole crop growth and development period as compared to later sown DSR and yield heavily depends on the dry matter accumulation at heading stage and solar radiation available at ripening phase (Biswanath *et al*., 2016) [7].

Variation in yield and yield components was observed due to genotypic differences of varieties. The variety GGV-05-01 recorded higher number of panicles per square meter (284.1), panicle length (22.8 cm), panicle weight (3.2 g) and total grains per panicle (256.4). This might be due to the reason that there was better crop growth at early stages. Higher test weight by GNV-10-89 (18.4 g) is due to its bolder seeds. The maximum grain and straw yield of GGV-05-01 (6079 and 7301 kg ha^{-1}) over GNV-10-89 (2.83%), RNR-15048 (5.30%) and BPT-5204 (14.90%) is due to higher dry matter accumulation, higher panicle length, increased 1000-grain weight, and more numbers of effective tillers which were determined by better climatic conditions as well as better phenological development of the crop. Hardinath-1 produced significantly higher grain yield (3.39 t ha^{-1}) and straw yield (6.07 t ha^{-1}) was reported by Dawadi and Choudhary (2013) [8].

Table 2: Number of panicles per square meter, panicle length (cm), panicle weight (g) and number of grains per panicle of direct seeded rice as influenced by different varieties under varied dates of sowing

(D) / (V)	Number of panicles per square meter					Mean	Panicle length (cm)					Mean	Panicle weight (g)					Mean	Number of grains per panicle					Mean
	D_1	D_2	D_3	D_4	D_5		D_1	D_2	D_3	D_4	D_5		D_1	D_2	D_3	D_4	D_5		D_1	D_2	D_3	D_4	D_5	
V_1	319.9	303.7	291.7	266.3	238.7	284.1	24.3	23.8	23.2	21.8	20.6	22.8	3.6	3.5	3.2	3.0	2.8	3.2	309.7	295.3	274.0	250.0	233.3	272.5
V_2	261.7	244.7	229.0	211.3	185.3	226.4	22.6	22.2	21.3	20.0	19.0	21.0	3.3	3.1	3.0	2.8	2.6	2.9	263.0	249.3	236.7	215.0	195.7	231.9
V_3	236.0	214.7	199.3	176.3	154.3	196.1	21.2	20.8	20.1	19.3	17.9	19.8	3.1	3.0	2.9	2.6	2.3	2.8	237.3	224.3	211.3	196.0	172.3	208.3
V_4	285.3	265.0	251.3	229.0	202.0	246.5	23.4	22.9	22.3	20.8	19.5	22.0	3.5	3.3	3.1	2.9	2.7	3.1	285.0	272.3	259.3	230.3	213.3	252.1
Mean	275.7	257.0	242.8	220.8	195.1		22.9	22.4	21.7	20.5	19.3		3.4	3.2	3.0	2.8	3.1		273.8	260.3	245.3	222.8	203.7	
	SEm±			C.D (p=0.05)			SEm±			C.D (p=0.05)			SEm±			C.D (p=0.05)			SEm±			C.D (p=0.05)		
(D)	6.0			17.33			0.40			1.17			0.07			0.21			8.80			25.41		
(V)	8.89			25.68			0.28			0.82			0.08			0.24			10.50			30.33		
(D X V)	11.48			NS			0.37			NS			0.11			NS			13.56			NS		

Note:

D: Dates of sowing
D_1: 2^{nd} Fortnight of June
D_2: 1^{st} Fortnight of July
D_3: 2^{nd} Fortnight of July
D_4: 1^{st} Fortnight of August
D_5: 2^{nd} Fortnight of August

V: Varieties
V_1: GGV-05-01
V_2: RNR -15048
V_3: BPT -5204
V_4: GNV-10-89

Table 2a: Test weight (g), grain yield (kg ha^{-1}) and straw yield (kg ha^{-1}) of direct seeded rice as influenced by different varieties under varied dates of sowing

(D) / (V)	Test weight (g)					Mean	Grain yield (kg ha^{-1})					Mean	Straw yield (kg ha^{-1})					Mean
	D_1	D_2	D_3	D_4	D_5		D_1	D_2	D_3	D_4	D_5		D_1	D_2	D_3	D_4	D_5	
V_1	17.6	17.4	17.1	16.9	16.4	17.1	6548	6509	6330	6192	4817	6079	7848	7810	7642	7425	5780	7301
V_2	16.8	16.6	16.3	16.0	15.6	17.3	6207	6163	6051	5839	4527	5757	7418	7234	7296	7075	5216	6848
V_3	16.3	16.3	15.7	15.4	15.0	15.8	5884	5433	5349	5094	4105	5173	7058	6391	6486	6198	4926	6212
V_4	19.1	18.8	18.4	18.1	17.7	18.4	6450	6383	6265	5908	4529	5907	7740	7645	7441	7000	5434	7052
Mean	17.6	17.5	17.1	16.9	16.5		6272	6122	5999	5758	4495		7516	7270	7216	6925	5339	
	SEm±			C.D (p=0.05)			SEm±			C.D (p=0.05)			SEm±			C.D (p=0.05)		
(D)	0.06			0.18			44.21			127.7			101.7			293.8		
(V)	0.06			0.17			25.3			72.9			38.0			109.8		
(D X V)	0.08			NS			32.6			94.2			49.1			141.8		

Note:

D: Dates of sowing
D_1: 2^{nd} Fortnight of June
D_2: 1^{st} Fortnight of July
D_3: 2^{nd} Fortnight of July
D_4: 1^{st} Fortnight of August
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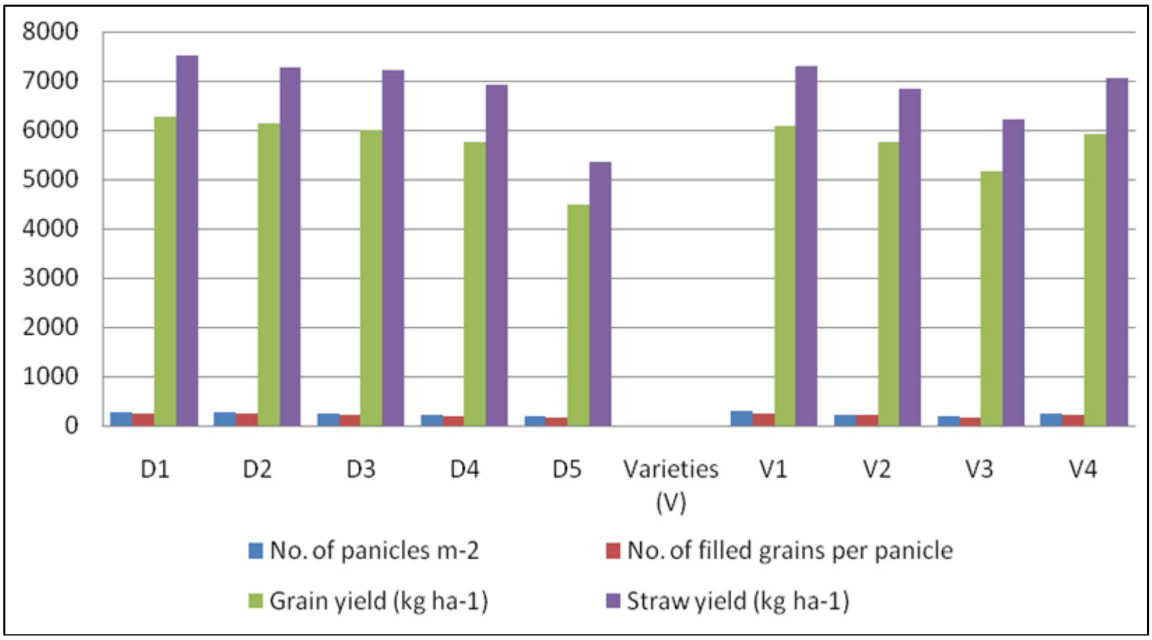

Fig 2: Number of panicles per square meter, number of filled grains per panicle, grain and straw yield influenced by different dates of sowing and varieties

Conclusion

From the experiment it can be concluded that, 2nd fortnight of June is the best sowing date as it recorded maximum growth and yield parameters and grain yield (6272 kg ha^{-1}). However farmer can take up sowing upto first fortnight of August. Wheres, among the varieties, GGV-05-01 followed by GNV-10-89 resulted in maximum growth parameters, yield attributes and grain yield (6079 kg ha^{-1}). For delayed sowing, short duration varieties *viz*., GGV-05-01, RNR-15048 or GNV-10-89 are suitable for getting higher grain yield.

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