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Response of mungbean (*Vigna radiata*. L. Wilczek) varieties to different sowing windows

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Abstract
Yield potential of mungbean is generally low. Various factors responsible for low yield of mungbean at the farmer's field are lack of awareness of farmers about optimum time of sowing, using high yielding variety, improper planting patterns, insufficient plant protection measures and imbalanced use of fertilizers. Sowing time, a non-monetary input is the single most important factor to obtain maximum yield from mungbean. Keeping the above facts in view, an experiment entitled "Response of mungbean [*Vigna radiata* (L.)] Varieties to different sowing windows" in south *Konkan* coastal zone on plot No.74 of Agronomy Department Farm, College of Agriculture, Dapoli, Dist. Ratnagiri during *Rabi* hot weather season of 2018-19. The trial was laid out in a strip plot design with four replications. The results revealed that, mungbean crop sown in 3rd MW (15-21 Jan.) with variety Dapoli Mung 1 produced higher growth and yield attributes, total biomass production as compared to other sowing windows and varieties. The crop sown in 3rd MW recorded highest grain yield (10.10 q ha^{-1}), stover yield (15.81 q ha^{-1}) and total biomass production (25.91 q ha^{-1}) over remaining sowing windows.

Keywords: Meteorological week (MW), Variety (V)

Introduction
Mungbean (*Vigna radiata* L. Wilczek) locally called as moong, mung or green gram belongs to family leguminoceae (fabaceae). It is reported to have (2n= 22) chromosome numbers. It is rapidly growing, erect or semi erect annual herb usually grow 40 to 120 cm in height and having deep root system. The leaves are trifoliate with large, ovate entire or rarely lobed membranous leaflets with scattered hairs on both sides. The pods are sub-cylindrical, long wide, and straight or slightly curved, 04 to 15 cm in length, small, globular and long, often green but may be yellow brown and speckled with black colour seeds.
It is considered the most wholesome among the pulses and free from heaviness and flatulence. The green pods of mungbean are used as vegetable and haulm is used as fodder for cattle. It is grown as cover crop and soil binder. It is an excellent green manure and easily decomposable. The nutritional value of green gram is high. It contains 22 to 24 per cent protein and 59.9 per cent carbohydrate. The dietary fibre of raw mungbean ranges from 23 to 24 per cent. This is rich in minerals, particularly Ca, Fe and K and contain good amount of riboflavin, thiamine and vitamin A. It contains about 75 mg calcium, 8.5 mg iron and 49 mg R- carotene 100 g^{-1} of split dal (Bhowmik *et al*, 2006) [1].

Materials and Methods
The soil analysis indicated that the experimental plot was sandy clay loam in texture, medium in available nitrogen (287.10 kg ha^{-1}) and phosphorus (14.78 kg ha^{-1}), high in available potassium (225.98 kg ha^{-1}), very high in organic carbon (13.28 g kg^{-1}) and slightly acidic in soil reaction (pH 6.52). Climatologically, this area falls in tropical region with hot and humid climate having mean annual precipitation of 3500 mm, which is normally received from June to October in about 95 to 100 rainy days.
The field experiment was laid out in a strip plot design. The main plot treatments comprised four sowing windows and the sub plots consisted of four varieties. Thus, there were sixteen treatment combinations, replicated thrice. The treatment details along with the symbols used in the layout plan are as follows.

Table 1: The main and sub plot treatment and its symbol.

Main plot treatments (Sowing windows)		
		Symbols used
1.	1st MW (1 to 7 January)	S_1
2.	3rd MW (15 to 21 January)	S_2
3.	5th MW (29 Jan to 4 February)	S_3
4.	7th MW (12 to 18 february)	S_4
Sub plot treatments (Varieties)		
		Symbols used
1.	Dapoli Mung 1	V_1
2.	BM 2003-2	V_2
3.	Vaibhav	V_3
4.	AKM 8802	V_4

The gross and net plot size were 4.5 m x 3.0 m and 3.9 m x 2.4 m respectively. The periodical observations of crop growth attributes and yield were recorded after seed emergence *w. e. f.* 15, 30, 45, 60 DAS and at harvest *viz*., plant population, plant height (cm), number of functional leaves plant^{-1}, leaf area plant^{-1} (dm^2), dry matter accumulation plant^{-1}(g), grain yield (q ha^{-1}) and stover yield (q ha^{-1}). The protein content in grain and stover were also calculated. The experimental data was statistically analyzed by using a standard method of "analysis of variance" as reported by Panse and Sukhatme (1967) [7].

A. Characteristics of varieties

The mungbean varieties Dapoli Mung 1, BM 2003- 2, Vaibhav and AKM 8802 were selected for study.

1. **Dapoli Mung 1:** This variety has been developed by Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. It is recommended for cultivation in rabi hot weather season in Konkan region. The duration of this variety is 71 to 75 days and height of the crop is 50 to 55 cm. The average yield of this variety is 12 to 15 q ha^{-1} which is 9 to 10 per cent more over the control.
2. **AKM 8802:** This variety has been developed by Dr. Punjabrao Deshmukh Krishi Vidyapeeth, Akola in the year 2000. It is cross between MH 1 and PIMS 4. It is green lustrous, bold grained, early seedling and vigor, red pigmentation on stem and vein. It matures in 57 to 68 days. This variety is resistant to powdery mildew and average yield is 10 to 11 q ha^{-1}. It contains 22 to 24 per cent protein.
3. **Vaibhav:** This variety is developed by MPKV, Rahuri during 2001. It is a cross between KDM 1 and IARM 18. It has green bold seeds, resistant to powdery mildew, suitable for Kharif and summer seasons. It is lustrous green with indeterminate growth, tall, semi spreading, green stem with sparsely pigmented growth habit. It matures in 70 to 75 days and average yield is 8 q ha^{-1}.
4. **BM 2003-2:** The variety BM 2003-2 was released by VNMKV, Parbhani during year 2010. The variety having drooping pod habit with pointed tip. The seed is bold, shiny and green color. Pod is long with prominent constriction contains 12 to 14 grains pod^{-1}. The important habit of this variety is synchronous maturity. And the variety is resistant to microphomina blight and powdery mildew and is developed by selection from Chirai local strain. It matures in 60 to 65 days and average yield is 7-8 q ha^{-1}.

B. Application of fertilizers

The quantity of fertilizer dose was calculated as per the recommended dose and applied required quantity plot-1 and mixed thoroughly in to the soil after layout.

Nitrogen and phosphorus were applied in the form of urea (46% N) and single superphosphate (16% P2O5) as per the treatments. The whole quantity of fertilizers was applied as a basal dose before sowing.

C. Sowing of mungbean

Sowing of mungbean was done as per sowing windows by using the seed rate of 20 kg ha-1 of each variety i.e. as per the treatments. Required quantity of healthy, bold, unbroken and fully developed seeds of mungbean varieties were inoculated with rhizobium @ 25 g kg-1 seed before sowing of the crop. Rows were marked on the field with the help of marker and biofertilizers treated seeds were sown at the spacing of 30 cm × 15 cm as per the treatments in each meteorological week. Two seeds were dibbled at each hill at about 3 cm depth. Seeds were properly covered with the soil to obtain uniform germination and plant stand.

Results and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads:

Growth parameters

A. Plant stand: The results in Table 2 indicate that sowing windows and varieties were did not significantly influenced the plant population at initial stages and at harvest. The plant population mungbean ha^{-1} counted at 20 DAS and at harvest did not differ significantly due to different sowing windows. This indicated that, the plant population was uniform in mungbean crop throughout its life cycle. Therefore, the variation observed in different growth, yield attributes and yield of mungbean in present investigation were entirely due to the imposition of different treatments only.

B. Plant height: Data in Table 2 revealed that the crop growth become faster from 15 to 60 DAS but thereafter the rate of increase in plant height was slow until harvest, irrespective of the treatments that is the growth pattern follows the sigmoid growth curve. The mean height of the mungbean recorded at harvest was 34.94 cm. The mungbean crop sown during 3rd MW produced significantly superior plant height throughout the life span of the crop fallowed by 1st MW, 5th MW and 7th MW in that descending order. The variety Dapoli Mung1 recorded significantly superior plant height than rest of the varieties followed by Vaibhav which was significantly superior over AKM 8802 and BM 2003-2 from 30 DAS to at harvest. These results are in agreement with the Gangwar *et al*. (2012) [2], Ram *et al.* (2000) [9], Patel *et al.* (2003) [8], Ram and Dixit (2001) [10].

Table 2: Effect of time of sowing (sowing windows) and different Varieties on growth attributing characters of Mungbean (*Vigna radiata* L. Wilczek)

Treatment	At harvest	Growth characteristics at 60 DAS			
	Plant stand ha^{-1} (percent)	Plant height (cm)	No. of leaves plant^{-1}	Number of branches plant^{-1}	Dry matter plant^{-1} (g)
A) Sowing windows					
S1	95.95	32.72	11.18	2.33	9.07
S2	95.95	34.36	11.54	2.65	10.41
S3	96.19	31.50	10.88	2.23	8.75
S4	95.83	30.49	10.55	2.18	8.39
S.Em ±	--	0.31	0.12	0.16	0.24
C.D. at 5%	--	1.07	0.41	0.55	0.82
B) Varieties					
V1	95.99	35.50	12.05	3.42	10.91
V2	95.95	29.24	10.13	1.40	7.39
V3	96.19	34.70	11.79	3.08	10.45
V4	95.83	29.63	10.18	1.50	7.87
S.Em ±	--	0.19	0.14	0.13	0.25
C.D. at 5%	--	0.58	0.43	0.40	0.76
C) Interaction Effect					
S.Em ±	--	0.99	0.50	0.38	1.11
C.D. at 5%	--	NS	NS	NS	NS
General mean	95.98	32.27	11.04	2.35	9.15

C. Number of functional leaves plant^{-1}: It is evident that the number of functional leaves went on increasing with the advancement in the age up to 60 DAS and thereafter showed decline up to harvest. Thereafter, the count declined on account of senescence conforming the count trend of crop growth. The mean number of functional leaves recorded at harvest was 8.00. At 30 DAS till at harvest, the crops sown during 3rd MW recorded significantly more number of functional leaves plant^{-1} than rest of the sowing windows and remain at par with 1st MW and 5th MW except at 60 DAS. At 30, 45, 60 DAS and at harvest variety Dapoli Mung 1 recorded maximum and significantly more number of functional leaves plant^{-1} than rest of the varieties at all the growth stages and remained at par with the variety Vaibhav.

D. Number of branches plant^{-1}: The mean number of branches plant^{-1} increased with increase in age of crop from 45 DAS. Maximum number of branches was recorded at harvest of the crop. The mean number of branches plant^{-1} recorded at harvest was 2.58. At 60 DAS and at harvest the crop sown during 3rd MW recorded significantly higher number of branches plant^{-1} over rest of the sowing windows. The variety Dapoli Mung1 recorded significantly more number of branches over rest of the varieties at 45 and 60 DAS which were at par with the Vaibhav variety followed by AKM 8802 and BM 2003-2.

E. Dry matter production plant^{-1}: It was found from the data that, the mean dry matter accumulation of mungbean was 0.13 g at 15 DAS which was gradually increased up to 10.86 g at the harvest. In general, mean dry matter accumulation plant^{-1} increased with increase in age of the crop and it was higher at harvest. At 60 DAS, 3rd MW recorded significantly superior dry matter plant^{-1} over the rest of treatments followed by treatments 1st MW, 5th MW and 7th MW in that descending order, which were remained at par with each other. At 60 DAS and at harvest, the variety Dapoli Mung1 and variety Vaibhav remained at par with each other and both these varieties has produced significantly higher dry matter plant^{-1} as compared to variety AKM 8802 and BM 2003-2 where they remain at par with each other.

Yield contributing characters

A. Number of pods plant^{-1}: The data in table 3 shows that, sowing mungbean during 3rd MW recorded significantly higher number of pods plant^{-1} (16.98) than rest of the sowing windows and remain at par with crop sown during 1st MW and 5th MW. Significantly the highest number of pod plant^{-1} was recorded by variety Dapoli Mung 1 (19.35) over rest of the varieties which were remain at par with variety Vaibhav.

B. Pod length: The mungbean crop sown during 3rd MW recorded significantly more pod length (8.05 cm) over the rest of the sowing windows but found at par with 1st MW. Variety BM 2003-2 recorded significantly the highest length of pod (8.18 cm) over rest of the varieties but remained at par with variety Vaibhav.

C. Number of grains pod^{-1}: Significantly maximum numerical value of number of grains pod^{-1} was recorded by 3rd MW (8.96) over rest of the treatments but remain at par with 1st MW. Significantly maximum numerical value the number of grains pod^{-1} was recorded by Dapoli Mung1 over rest of the varieties which were remained at par with variety BM 2002-3.

D. Weight of pod: The mungbean crop sown during 3rd MW produced significantly superior weight of pod (13.01 g) than the rest of the sowing windows fallowed by 1st, 5th, and 7th MW in that descending order. Variety Dapoli Mung 1 was recorded significantly superior weight of pod plant $^{-1}$ (16.34 g) over rest of varieties.

E. Test weight: significantly maximum numerical value of test weight was recorded by sown during 3rd MW (4.20 g) over rest of the sowing windows which remained at par with 1st MW. Significantly superior test weight was obtained in bold seeded variety BM 2003-2 (4.39 g) over rest of the varieties. These observations are in line with the finding reported by Ram and Dixit (2001) [10], Khot *et al.* (2016) [4], Ram *et al.* (2000) [9], Sarker *et al.* (2004) [11], Miah *et al.* (2009) [6], Gurusharan and Sharma (2004) [3] and Kumar *et al.* (2015) [5].

Table 3: Mean yield contributing characters of mungbean as influenced by different treatments:

Treatment	Total number of pods plant^{-1}	Length of pod (cm) plant^{-1}	Number of grains pod^{-1}	Weight of pod plant^{-1} (g)	Test wt (g)	Grain yield (g) lant^{-1}	Stover yield (g) plant^{-1}
A) Sowing windows							
S_1: 1st MW (1- 7 Jan.)	16.74	7.83	8.68	12.08	4.18	5.54	7.43
S_2: 3rd MW (15- 21 Jan.)	16.98	8.05	8.96	13.01	4.20	5.90	8.45
S_3: 5th MW (29 Jan.- 4 Feb.)	15.61	7.45	8.55	11.31	4.13	4.98	6.76
S_4: 7th MW (12- 18 Feb.)	14.88	7.41	8.48	10.68	4.12	4.66	6.53
S.Em ±	0.51	0.11	0.13	0.23	0.02	0.07	0.10
C.D. at 5%	1.77	0.38	0.44	0.80	0.05	0.23	0.35
B) Varieties							
V_1: Dapoli Mung 1	19.35	6.55	9.90	16.34	4.01	6.56	8.39
V_2: BM 2003-2	12.77	8.18	9.16	7.18	4.39	4.14	6.16
V_3: Vaibhav	18.54	8.03	8.22	14.40	4.14	5.75	7.68
V_4: AKM 8802	13.54	7.97	8.20	9.15	4.09	4.64	6.94
S.Em ±	0.56	0.15	0.13	0.28	0.02	0.07	0.07
C.D. at 5%	1.66	0.46	0.38	0.84	0.06	0.20	0.20
C) Interaction effect							
S.Em ±	1.37	0.30	0.36	0.84	0.05	0.21	0.39
C.D. at 5%	NS	NS	NS	NS	NS	SIG	NS
General mean	16.05	7.68	8.67	11.77	4.16	5.27	7.29

F. Grain yield plant^{-1}: The grain yield plant^{-1} was remarkably influenced due to the different sowing windows and varieties. Significantly the superior grain yield plant^{-1} was recorded by 3rd MW (5.90 g) over rest of the sowing windows followed by 1st, 5th and 7th MW in that descending order. Among the different treatments, significantly superior grain yield plant^{-1} was recorded by variety Dapoli Mung 1 (6.56 g) over rest of the varieties followed by varieties Vaibhav, AKM 8802 and BM 2003-2 in that descending order. The interaction effect among various sowing windows and varieties in case of grain yield plant^{-1} of was found significant.

G. Stover yield plant^{-1}: The crop sown during 3rd MW recorded significantly superior stover yield (8.45 g) plant^{-1} over the rest of the treatments followed by 1st, 5th, 7th MW in that descending order. Among the different varieties Dapoli Mung 1 recorded significantly superior stover yield plant^{-1} (8.39 g) than rest of the treatments followed by variety Vaibhav, AKM 8802 and BM 2003-2 in that descending order. The interaction effects among different sowing windows and varieties in case of stover yield plant^{-1} recorded at harvest was found not significant. These results conform to the finding reported by Khot *et.al* (2016) [4], Gangwar *et al.* (2012) [2].

Summary and Conclusion

Based on the current field experiment results, the growth attributing studies *viz*., plant height, number of functional leaves, number of branches plant^{-1} and dry matter production of mungbean were significantly influenced due to different sowing windows at all growth stages except 15 DAS. The 3rd MW recorded significantly higher plant height, number of functional leaves and dry matter production as compared to 3rd, 5th and 7th MW. In case of various yield attributing characters under study *viz*., total number of pods plant^{-1}, length of pod^{-1}, number of grain pods^{-1}, weight of pods plant^{-1}, 100 grain weight and grain weight plant^{-1}, stover weight plant^{-1} recorded significantly higher values at 3rd MW sowing as compared to other sowing dates. In sub plot, the growth attributing studies *viz.* plant height, number of functional leaves and dry matter production were significantly influenced due to different varieties at all stages of crop except 15 DAS. In case of various yield attributing characters under study *viz*., total number pods plant^{-1}, weight of pods plant^{-1}, grain weight plant^{-1}, stover weight plant^{-1} and number of grain pods^{-1} except 100-grain weight, length of pod^{-1} recorded significantly higher in Dapoli Mung 1 as compared to other varieties. The 100-grain weight, length of pod recorded significantly higher in BM 2003-2.

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