Research Article

Effective Flower Production at Various Flushes and their Respective Contribution Towards Final Yield of Mungbean

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Abstract | Current experiment was performed in 2019 at Arid Zone Research Center, Dera Ismail Khan, KP, to study Mungbean (*Vigna radiata* L.) flushes and their contribution towards the final yield. Among the goals were the quantification of mungbean flowering flushes to final yield, identification of short duration variety, to recognize varieties suitable for water-deficient areas, and varieties suitable for cotton crop intercropping before reaching their maximum canopy level. The analysis was carried out in randomized complete block design (RCBD) with three replications of split plot arrangement; varieties (NM-2011, Inqelab Mung, Dera Mung, and NM-98) were allocated in the main plot and sub-plots were held at various flowering flushes. The analyzed data revealed that the percentage of pods plant^{-1}, weight pod^{-1}, 1000 grain weight, grain yield, and harvest index were significantly affected by different varieties, and their interaction with the harvest at various flowering flushes. Inqelab Mung give higher yield compared to other varieties by producing 26 and 37 percent (63 percent) of its total yield in the 1st and 2nd flushes, respectively, with maturity for both flushes in around 63 days. In addition, its yield was higher than NM-2011, Dera Mung, and NM-98 by 21 %, 51 %, and 40 %, respectively. Cultivar Inqelab Mung may be recommended for planting in rain-fed conditions where the supply of water for the second and third irrigation is uncertain for farmers. In addition, through adding nitrogen via nodulation, it can also be intercropped with cotton as it can give fair yield without presenting any competition with cotton crop.

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Keywords | Mungbean, Mungbean flashes, nodulation, Grain yield

Introduction

Mungbean (*Vigna radiata* L.) is a short duration and widely adaptable kharif pulse crop. It occupies an important place in intensive cropping system of Pakistan. In Pakistan mungbean is grown on 172.9 thousand hectares with production of 125.9 thousand tones and an average yield of 728 kg ha^{-1} (Anonymous, 2019-20). Mungbean has indeterminate flowering habit and bear flowers in different flushes, therefore, varieties having both synchrony in flowering and maturity can be manipulated for increased productivity with least vulnerability to climatic affects in the field. Legume crops may produce many flowers but pods set from only a few flowers. Flower shedding is main problem in leguminous crops, in soybean crop it ranges from 60 to 92% (Saitoh *et al*., 2004), 70 to 90% in mungbean (Mondal *et al*., 2011), 80 to 91% in kidney bean (*Vigna unguiculata*) (Hossain *et al*., 2006), and 80 to 95% in pigeon pea (*Cajanus cajan*) (Begum *et al*., 2007). It was found that comparatively higher fraction of reproductive abscission in legumes may be due to later-formed flowers, that cannot receive enough assimilates to complete pod formation (Mondal *et al*., 2011); which may be due to inadequate phloem tissues' in distal portion of raceme (Begum *et al*., 2007). It results in abscission of flowers and immature pods formation in leguminous crops (Hossain *et al*., 2006). The yield of legumes can be amplified by reducing the abscission percentage. The issue is much deliberated among scientific community; whether yield in leguminous crops is source or sink limited. Whilst most of the arguments favor that the earlier-formed pods were heavier in size and weight than the pods set at later stage (Begum *et al*., 2007; Kuroda *et al*., 1998; Mondal *et al*., 2011) indicating thereby the inadequate supply of assimilates at later stage. The genotypes producing more flowers in comparatively shorter period; set higher number of pods and retaining them till final maturity (Biswas *et al*., 2004). Similarly, it was noticed that the plants which produces more flowers within 2 to 3 weeks after 1st flowering showed higher pod yield as compared to others in mungbean and groundnut (Mondal and Hamid, 1998). Flowers shedding observed under high temperature in segregating population, mutants, and recombinant of local and exotic mungbean genotypes (Khattak *et al*., 2009). Moderate tolerance (10-20 %) was noted in recombinants/mutants and more than 40% were rated susceptible due to flowers shedding. It was tried to improve the understanding in dynamics of occurrence in second flowers' flush and their quantification regarding share in final grain yield. The share of the 2nd flush in total yield was higher where the crop was under stress during mid-vegetative growth period. The 2nd flush was even poorer or merely absent under terminal drought conditions. Grain quality of the 1st flush was adversely affected while waiting for maturity of the 2nd flush due to rainfall after the maturity of the 1st flush (Khattak *et al*., 2009).

Hence, physio-morphological foundations of flower development and its pattern which leads to the production of more mature pods and increased final yield; needs to be accurately assessed in mungbean for its sowing in water scarce areas and its intercropping with cotton crop. In this experiment we investigated production of effective flower flushes and their competence in the yield of four mungbean genotypes while harvesting them at three flowering flushes in irrigated plain of Dera Ismail Khan, Pakistan. Such studies would help exploring suitable and efficient variety of mungbean that not only perform well in rainfed areas but may also be grown successfully as intercrop with cotton, which covers almost all the irrigated area of Pakistan. Furthermore, it seems imperative for survival of mungbean as a main pulse crop during summer season in Asian countries; besides filling the gap in cropping system without competing directly with major kharif crops like rice and cotton.

Materials and Methods

This experiment was conducted at Arid Zone Research Center, Dera Ismail Khan, in a randomized complete block configuration with split plot structure. In the main plot, the varieties (NM-2011, Inqelab Mung, Dera Mung, and NM-98) were retained while the various flowering flushes (03) were kept in sub-plots. The plants were spaced at 10 cm with rows 30 cm apart, maintaining a plot size of 1.8 x 4m^2. Fertilizer was administered as a baseline dose at 20:50 (N and P) kg ha^{-1}. The experiment was analyzed statistically using "MstatC" computer software. All other cultural operations in all treatments before harvesting were kept standardized. The details of treatments are given in the following (Table 1). Agro-Meteorological Data Recorded at Arid Zone Research Centre, PARC, D.I. Khan during the present study are given inthe Table 2.

Table 1: *Varieties used during the current study.*

(V)	**Varieties**
V1	NM-2011
V2	Inqelab Mung
V3	Dera Mung
V4	NM-98
HF	**Harvest at Flushes**
HF1	Harvest at 1st flush maturity
HF2	Harvest at 2nd flush maturity
HF3	Harvest at 3rd flush maturity

Results and Discussion

It is evident from Table 3 that number of pods plant^{-1} was positively affected by different varieties. Single

Table 2: *Agro-Meteorological Data Recorded at Arid Zone Research Centre, PARC, D. I. Khan during this study.*

Date	Temp. °C		Humidity %		Screen pan evaporation (mm/day)	Wind speed (km/day)	Rain fall (mm)
	Max	Min	0800 hrs	1400 hrs			
June, 2019							
1	41	23	44	21	6.07	2.46	-
2	40	28	49	21	7.84	2.25	-
3	44	29	41	19	7.92	3.58	-
4	44	33	46	21	7.70	2.62	-
5	43	32	56	19	7.90	2.29	-
6	44	36	51	21	8.05	3.58	-
7	41	27	36	24	9.48	2.79	-
8	40	28	36	21	9.58	2.58	-
9	44	28	51	21	8.32	1.95	-
10	44	25	51	20	7.03	1.66	-
11	44	24	51	19	7.01	3.91	-
12	40	29	36	24	8.45	3.54	-
13	44	25	50	21	7.92	3.21	-
14	39	28	56	18	8.35	3.41	-
15	37	28	56	24	6.60	9.66	-
16	38	29	56	19	7.17	1.66	-
17	38	30	43	21	7.10	3.12	-
18	44	32	48	21	7.23	3.25	-
19	43	25	51	45	6.07	1.62	-
20	42	27	56	45	6.33	2.75	-
21	44	29	56	38	6.15	4.45	-
22	42	26	59	34	7.85	3.25	-
23	41	26	77	34	7.11	2.50	-
24	42	27	70	28	6.30	2.66	15
25	40	27	64	30	6.40	4.79	-
26	35	19	81	62	6.22	2.12	-
27	36	29	78	34	6.18	2.95	-
28	37	30	52	21	7.08	4.54	-
29	34	23	65	21	7.45	4.41	-
30	36	30	65	34	7.11	4.50	-
Avg.	41	28	53	27	7.37	3.00	Total Rainfall= 15 mm
Max.	44	-	78	62	9.58	9.66	
Min.	-	19	36	18	6.07	1.62	
July, 2019							
01	32	29	71	46	2.80	2.58	-
02	34	28	78	55	1.15	3.44	-
03	32	25	92	48	2.14	3.27	-
04	35	25	81	48	1.36	3.00	-
05	37	27	65	48	1.33	4.95	-
06	38	23	76	48	2.00	1.67	-
07	35	28	82	46	1.05	2.33	-
08	39	28	47	46	1.00	1.92	-
09	35	28	78	44	2.80	1.04	-
10	39	30	81	47	1.45	1.57	-
11	44	30	78	44	2.90	3.04	-
12	43	28	72	36	2.86	1.15	-
13	36	25	75	47	2.88	3.42	-
14	44	32	63	44	1.20	7.44	-
15	35	32	78	56	2.94	1.88	-
16	44	24	68	48	2.29	2.92	-
17	36	25	70	40	2.89	4.08	-
18	35	25	93	46	2.04	3.55	-
19	36	29	70	74	2.48	1.17	-
20	35	29	72	47	2.20	3.08	-
21	37	28	74	50	1.00	1.79	-
22	39	30	74	53	1.32	1.85	-
23	35	18	68	40	1.00	1.58	-
24	38	30	62	58	1.16	1.54	-
25	39	28	56	40	1.07	2.53	-
26	40	30	67	33	2.91	1.50	-
27	38	25	78	40	2.12	2.95	02
28	40	30	56	40	2.15	2.00	-
29	38	28	56	40	2.17	2.29	-
30	40	30	54	47	1.28	2.92	-
31	39	25	58	36	1.24	2.45	-
Max.	44	-	92	74	4.33	7.44	Rainfall= 02 mm
Min.	-	15	47	35	1.04	1.15	
August, 2019							
01	41	24	68	40	4.20	2.83	-
02	35	20	55	41	4.20	2.71	-
03	36	22	73	36	4.30	3.33	32
04	38	20	62	34	4.60	3.58	-
05	39	24	59	49	3.80	3.00	-
06	36	24	59	41	3.60	2.08	-
07	38	25	62	34	4.10	3.17	-
08	40	30	65	32	4.00	3.04	-
09	39	23	62	34	3.90	3.33	-
10	37	21	55	28	3.80	2.83	-
11	38	26	59	32	3.60	3.46	-
12	38	23	70	41	3.50	2.58	-
13	34	20	55	27	3.70	2.42	-
14	35	22	59	34	3.60	3.08	-
15	34	25	55	28	3.90	3.46	-
16	38	22	61	30	5.20	2.38	-
17	44	24	42	26	3.40	3.58	-
18	36	22	59	41	3.90	2.29	-
19	36	25	59	34	3.70	8.95	-
20	35	24	55	41	3.80	2.67	17
21	37	26	59	36	3.50	2.92	-
22	35	23	55	32	5.10	3.08	-
23	34	19	55	36	5.30	3.42	-
24	36	21	52	36	5.20	3.67	-
25	35	22	52	41	5.40	3.38	-
26	38	24	55	32	5.30	3.00	-
27	36	20	59	30	3.00	4.58	-
28	35	20	62	30	4.60	2.50	-
29	38	24	61	49	4.20	2.08	-
30	35	21	65	32	2.90	4.00	-
31	34	20	70	44	4.20	2.33	-
Avg.	36	23	59	35	4.12	3.00	Total Rainfall= 49 mm
Max.	41	-	73	49	5.40	4.58	
Min.	--	20	42	26	2.90	2.08	

Note:- *Average of temperature, relative humidity and wind speed is rounded to whole numbers. The evaporation data is collected from U.S.W.B.class. 'A' pan covered with a screen.*

plant of Inqelab Mung possessed highest number of pods plant^{-1} (15.62) which was greater than NM-2011 (13.57), NM-98 (11.39) and Dera Mung (7.75) respectively. Data further depicted maximum pods (18.19) at 3rd flush as compared to 2nd (11.6) and 1st (6.45) flushes, respectively, amplifying the role of plant age.

Table 3: *Number of pods plant^{-1} as affected by harvest at various flushes in mungbean varieties.*

Varieties	Harvest at flushes			Means
	HF1	HF2	HF3	
NM-2011	6.7e	14.4bc	19.6a	13.57b
Inqelab Mung	10.2d	15.1b	21.6a	15.62a
Dera Mung	5.0ef	6.1ef	12.1cd	7.75d
NM-98	3.9f	10.9d	19.4a	11.39c
Means	6.45c	11.60b	18.19a	

Means followed by different letters are significant at 5% level of probability. LSD $_{0.05}$ for varieties= 1.528; LSD $_{0.05}$ for harvest at flushes= 2.428; LSD $_{0.05}$ for interaction= 2.428

Harvest time and varietal interaction demonstrated highest number of pods (21.6) in Cv. Inqelab Mung, followed by NM-2011 (19.6) and NM-98 (19.4) at 3rd flush. However, NM-98 yielded least number of pods (3.9) at 1st harvest. The increased number of pods in case of Inqelab Mung may be attributed to improved flowering within stipulated period; which is in conformity with (Mondal *et al*., 2011), who noted an increase in number of flowers produced within 10 to 15 days after flowering initiation in mungbean. It was reported that early formation of flowers showed more pod setting as compared to later flower formation (Spollen *et al*., 1986); this might be due to the fact that most of the assimilates produced by leaves were used in filling the pods that produced at proximal position of raceme.

As per the mean data presented in Table 4, grain number per pod exhibited non-significant variation for different varieties. However, on average 10 grains per pod were recorded in Cv. NM-2011, followed by Inqelab Mung with 9.93 grains pod^{-1}. Moreover, it is obvious from results that numerically higher number of grains in 1st (10.1) and 3rd (10.4) flushes was noticed in NM-2011 while in second flush of flowering and third flush of flowering maximum grains (9.9 and 10.16) were witnessed in Inqelab Mung. Increased number of grains may be due to effective transfer of assimilates during early stage of plants (Spollen *et al*., 1986); their data indicated that most of the carbohydrates produced by leaves are utilized in pod filling which were produced at early growth stage.

Table 4: *Number of grains pod^{-1} affected by harvest at various flushes in mungbaen varieties.*

Varieties	Harvest at flushes			Means
	HF1	HF2	HF3	
NM-2011	10.10 NS	9.53	10.40	10.00 NS
Inqelab Mung	9.80	9.90	10.16	9.93
Dera Mung	9.80	9.63	9.66	9.69
NM-98	9.30	9.73	9.30	9.44
Mean	9.73NS	9.69	9.88	

Average 1000 grain weight of Dera Mung was 37.19 g that was 5.02, 5.03 and 25.46% lesser than average 1000 grain weight of NM-2011, Inqelab Mung and NM-98, respectively (Table 5). Time passage had no impact on 1000 grain weight, noted as 40.79, 40.63, and 40.03 g at 2nd, 1st and 3rd flush. Grains of NM-98 have 47.16, 46.43, and 46.36 g weight at 2nd, 1st and 3rd flushes, respectively, that were maximum, while Dera Mung grains yielded the least weight at each harvest.

Table 5: *Thousand grain weights (g) affected by harvest at various flushes in mungbaen varieties.*

Varieties	Harvest at flushes			Means
	HF1	HF2	HF3	
NM-2011	39.30c	39.00cd	38.80cd	39.03b
Inqelab Mung	39.36c	39.26c	38.53d	39.06b
Dera Mung	37.46e	37.73e	36.36f	37.19c
NM-98	46.36b	47.16a	46.43b	46.66a
Mean	40.63ab	40.79a	40.03b	

Means followed by different letters are significant at 5% level of probability. LSD $_{0.05}$ for varieties= 0.311; LSD $_{0.05}$ for harvest at flushes= 0.613; LSD $_{0.05}$ for interaction= 0.697

Grain yield was significantly affected by different Mung varieties (Table 6). During this study, 4405 kg of grains were obtained from Inqelab Mung, 17.8, 51.4, and 28.5% greater in yield than NM-2011, Dera Mung, and NM-98, respectively. It is evident from mean data that combined yield of 1st and 2nd flushes of Inqelab Mung was 2448 kg ha^{-1}, 21 %, 51%, and 40% greater than NM-2011, Dera Mung, and NM-98, respectively; showing the supremacy of Inqelab Mung in terms of yield at 1st and 2nd flushes. It is therefore suggested to incorporate Inqelab Mung in inter cropping with cotton and for getting maximum yield in shorter time in cropping pattern of rain fed areas.

Table 6: *Grain yield (Kg ha^{-1}) as affected by harvest at various flushes in mungbaen varieties.*

Varieties	Harvest at flushes			Means
	HF1	**HF2**	**HF3**	
NM-2011	663efg	1269bcd	1691ab	1208 ab
Inqelab Mung	1062cde	1386bc	1957a	1468 a
Dera Mung	553fg	648efg	942def	714 b
NM-98	387g	1071cde	1691ab	1050ab
Means	666.3c	1094.0b	1570.0a	

Means followed by different letters are significant at 5% level of probability. LSD $_{0.05}$ for varieties= 558.2; LSD $_{0.05}$ for harvest at flushes= 374.2; LSD $_{0.05}$ for interaction= 425.6

It is also evident from mean harvest data that grain output recorded in 3rd flush yielded 1570 kg ha^{-1}, greater than 1094 and 666 kg ha^{-1} at 2nd and 1st harvests, respectively. In flowering flushes contribution, it was obvious that all tested varieties yielded maximum grain yield at third flush, however, Inqelab Mung produced 1956.6 kg ha^{-1} grains at 3rd harvest which was significantly greater than others (Table 7). As per our focus on maximum yield in earlier flowering flushes; the Cv. Inqelab Mung out yielded other varieties. Earlier findings (Saitoh *et al*., 1998) support the opinion that grain yield is source restricted at the late reproductive stage. It was found that the rachis diameter and radial length of xylem, phloem, and vascular tissues reduced at the distal end as compared to proximal position (Mondal *et al*., 2011).

Table 7: *Flush wise yield and its %age contribution in final yield.*

Varieties	Flush wise yield Kg ha^{-1}(%age)			Final yield
	1st flush	**2nd flush**	**3rd flush**	
NM-2011	663 (39%)	606 (36%)	422 (25%)	1691
Inqelab Mung	1062 (54%)	324 (17%)	571 (29%)	1957
Dera Mung	553 (59%)	95 (10%)	294 (31%)	942
NM-98	387 (23%)	684 (40%)	620 (37%)	1691
Means	666 (42%)	427 (28%)	477 (30%)	1570

The data for harvest index, as presented in Figure 1, showed that Inqelab Mung had 7.39% HI, followed by 5.56, 4.65 and 3.93% of NM-2011, NM-98 and Dera Mung, respectively. But non-significant difference in harvest index was found at various flushes, ranging from 5.21% at 3rd flush to 5.5% at 1st flush. Interaction of flushes and varieties was also found insignificant.

The obtained results might be attributed to the fact that structural development of phloem might have been poor at distal portion of the raceme; which posed insufficient transfer of photo-synthetic material to flowers/ pods formed during late stage and might be the main cause for flower shedding at the distal end of the raceme. It further indicates that the decreased yield in mungbean may possibly be conferred to limitation of vascular tissue at the distal end of rachis. Almost same pattern of results was recorded in soybean (Wiebold and Panciera, 1990), lignosus bean by Bari and Prodhan (Bari and Prodhan, 2001), and in pigeon pea by Begum *et al*. 2007. It was also noticed that with the increase in number of flowers per raceme; the ratio of pod setting per raceme decreased (Saitoh *et al*., 1999), however, total number of pods set per raceme increased thereby resulting in increased number of pods per raceme.

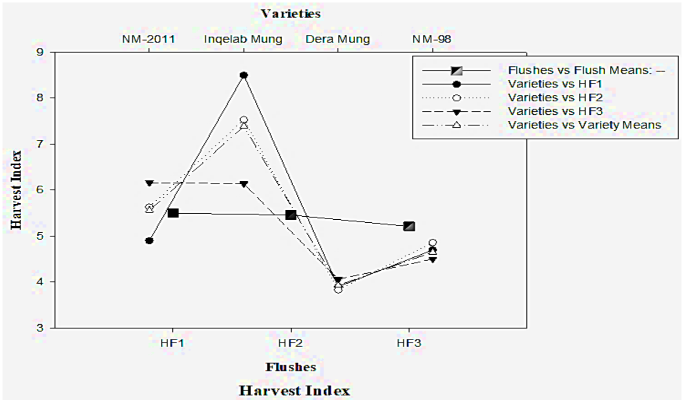

Figure 1: *Harvest index of the currently evaluated cultivars.*

Conclusions and Recommendations

In this study Inqelab Mung, Dera Mung, and NM-98 have been tested for different parameters contributing in to final yield. Inqelab Mung out yielded other varieties by producing 26 and 37% of its total yield in 1st and 2nd flushes, respectively, in approximately 63 days at maturity of both flushes. Inqelab Mung is recommended for rain-fed conditions where the availability of water for second and third irrigation is not guaranteed by farmers. Besides, Inqelab Mung is recommended for cotton intercropping as it can give fair yield without any competition with the cotton crop.

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Novelty Statement

First two flushes contribute Maximum in mungbean final yield.

Author's Contribution

Muhammad Mansoor: Conceived the idea and prepared the first draft of manuscript.
Sheheryar: Did statistical analysis.
Shahid Ali Khan: Submitted and revised the manuscript.

Conflict of interest
The authors have declared no conflict of interes.

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