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RELATIONSHIPS OF FLOWERING DURATION, FLOWERS AND REPRODUCTIVE EFFICIENCY WITH YIELD AND YIELD ATTRIBUTES OF LENTIL VARIETIES/MUTANTS

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ABSTRACT

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Lentil is an important pulse crop with high protein content,has the potential capacity to combat nutritional deficiencies in developing countries. Three pot experiments were carried out at BINA, Mymensingh, Bangladesh during winter seasons of 2017-18, 2018-19 and 2019-20 to see the flowering pattern and relationship of flower production, reproductive efficiency and flowering duration with yield attributes and yield of lentil varieties/mutants. The experiment was laid out in a Completely Randomized Design with three replications. Flower production showed differential peak at the middle of flowering duration. Days to flowering ranged from 48-60 days and the flowering duration from 15 to 24 days after flowering started. Total flower number plant^{-1} ranged from 234 to 686 and reproductive efficiency from 31.3 to 75.5%. Binamasur-6, Binamasur-7 and BARI Masur-4 hadhigher reproductive efficiency. Biological yield plant^{-1} ranged from 7.40 to 19.21 g and yield plant^{-1} from 3.10 to 7.51 g. Most of the mutants and Binamasur-8 produced higher biological and seed yield with better harvest index. Number of flowers plant^{-1} was correlated with biological yield, pods plant^{-1}, and negatively correlated with reproductive efficiency. Biological yield was also correlated with pods plant^{-1}. Pods plant^{-1} was correlated with reproductive efficiency and seed yield plant^{-1}. Seed yield plant^{-1} was correlated with pods plant^{-1} and seeds pod^{-1}. But these relationships did not equally exist in three years and no relationship was found between flowering duration and yield. Relationship was not also found between pods plant^{-1}, seeds pod^{-1} and 100-seed weight.

Key words: *relationship, flower, reproductive efficiency, yield, lentil*

INTRODUCTION

Lentil (*Lens esculenta* Medik.) is an important pulse crop with high protein content, has the potential capacity to combat nutritional deficiencies in developing regions and countries. It is commonly grown under rain fed condition, conserves moisture from preceding monsoon season and usually faces water stress (Islam and Akter, 2019; Islam and Ferdousi, 2006; Helali *et al.* 2002; Islam *et al*. 1998; Salam and Islam, 1994). In Bangladesh, lentil sowings occasionally get postponed because of the delayed harvest of the preceding crop, mostly T. Aman rice. As a result, the lentil crop at the time of grain filling stage suffers due to rising high temperatures. So, during the seed-filling stage, the crop is then adversely affected by the high approaching summer temperatures, leading to low grain yields and poor grain quality (Islam 2020; Tickoo *et al*. 2005). High temperature and water stress are significant abiotic stresses that limit production worldwide (Sehgal *et al*. 2017; Gaur *et al*. 2015). Yield potential of lentil is low and about 80-90% of lentil flowers do not develop into mature pods (Sinha 1977). Research on lentil flower production, flowering duration and pod production and interrelationship is inadequate and hence the understanding of the physiological basis of yield is limited. Setia *et al*. (1989) studied the number of flowers plant^{-1} and varied between 400-600 and that of pod setting between 13 to 15% in lentil genotypes. Lentil yield could be improved by increasing flower and pod (sink) (Kumar *et al*. 2008; Tambal *et al.* 2000). Therefore, it is necessary to investigate the relationship of flowers and yield in lentil. These three experiments focused on investigating the relationship of flower production, flowering duration and reproductive efficiency with yield attributes and yield of 10 lentil varieties and 5 mutants.

MATERIALS AND METHODS

Three pot experimentswere carried out at BINA pot yard, Mymensingh during winter seasons of 2017-18, 2018-19 and 2019-20. Each pot contained 8 kg soil. The experiment was laid out in a Completely Randomized Design with three replications. Recommended dose of fertilizers was applied and other cultural practices were followed as and when required. Flowers counts were recorded from each plant of each replication just from the date of first flowering there after every day up to flowering ceased. At harvest, seed yield and yield attributes were recorded. Per cent pod set to opened flowers (reproductive efficiency, RE) was then estimated as: % pod set = (Number of pod plant^{-1} ÷ Number of opened flowers plant^{-1}) × 100. The collected data were analyzed statistically.

RESULTS AND DISCUSSION

Daily flowering converted to 3-day interval had shown differential peak at the middle of flowering duration (Table 1, 3 and 5). Days to flowering ranged from 48-60 days and the flowering duration from 15 to 24 days after flowering started. Total flower number ranged from 234 to 686 and reproductive efficiency from 31.3 to 75.5% (Table 1-6). Binamasur-6, Binamasur-7 and BARI Masur-4 showed higher reproductive efficiency. Biological yield plant^{-1} ranged from 7.40 to 19.21 g and yield plant^{-1} from 3.10 to 7.51 g. Most of the mutants and Binamasur-8 produced higher biological and seed yield with better harvest index.

Number of flowers plant^{-1} was correlated with biological yield and pods plant^{-1}, biological yield was correlated with pods plant^{-1}, and pods plant^{-1} was correlated with seed yield plant^{-1}(Table 7). Number of flowers was

negatively correlated with reproductive efficiency, biological yield was correlated with pods plant^{-1}, and pods plant^{-1} was also correlated with seed yield plant^{-1} (Table 8). Pods plant^{-1} was correlated with reproductive efficiency and seed yield plant^{-1}, and seed yield plant^{-1} was correlated with pods plant^{-1} and seeds pod^{-1} (Table 9). The results partially agree with Kumar *et al.* 2008 and Tambal *et al.* 2000. Flowering duration and seed yield had no correlation. Relationship was not also found between pods plant^{-1}, seeds pod^{-1} and 100-seed weight.

Correlation results reveals that number of total flowers have no direct relation with seed yield but its relationship lies with biological yield and pods plant^{-1}. On the other hand, biological yield was positively correlated with pods plant^{-1}, so lentil plants should have sufficient dry mass for higher number of pod formation ultimately increased yield. Although reproductive efficiency had no direct relation with seed yield but it was correlated with pods plant^{-1}. So, total flowers production,reproductive efficiency and biological yield have no direct relation with seed yield in lentil andthose have positive correlation with other parameters correlated with seed yield. However, this relationshipwas not similarly prevailed in three years.

Table 1. Flowering pattern at 3 days interval of ten lentil varieties during winter season of 2017-18

Varieties	Days to flowering	Number of opened flowers at 3 days interval								Total flowers plant^{-1} (no)
		Days after flowering start								
		0-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24	
Binamasur-2	58a	24d	59d	110d	49e	65cd	59c	51b	11b	428d
Binamasur-4	60a	39b	49f	81e	160a	138a	48d	0	0	515b
BARI Masur-5	50b	29c	52f	62f	64d	82b	89a	67a	17a	462c
Binamasur-10	50b	26cd	57e	69ef	46ef	50e	70b	45b	17a	382e
Binamasur-5	50b	23d	68c	58fg	86c	70c	44de	21c	0	370e
Binamasur-7	51b	28c	110a	118c	60d	59d	43e	0	0	418d
Binamasur-3	60a	59a	67c	140b	105b	14g	0	0	0	385e
Binamasur-9	51b	10e	39g	66f	63d	85b	73b	69a	21a	426d
Binamasur-6	51b	29c	60d	54g	45f	44f	22f	0	0	254f
Binamasur-8	51b	36b	98b	169a	106b	142a	95a	40	0	686a
CV (%)	1.51	9.08	8.88	13.98	10.45	14.43	17.06	21.54	25.12	13.55

Same letter (s) in a column indicates do not differ significantly at P≤ 0.05

Table 2. Variation in reproductive efficiency, days to maturity, biological yield, yield attributes and seed yield of 10 lentil varieties during winter season of 2017-18

Varieties	Reproductive efficiency(%)	Days to maturity	Biological yield (g plant^{-1})	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	100-seed weight (g)	Seed weight plant^{-1} (g)	Harvest Index (%)
Binamasur-2	44.4ab	106b	15.81bc	190.4b	1.65ab	1.91c	5.99c	35.88bc
Binamasur-4	40.4b	110a	16.44ab	206.0ab	1.69a	1.60e	5.57cd	31.88f
BARI Masur-5	32.7d	106b	14.76cd	151.0c	1.63b	2.15a	5.55d	35.60bcd
Binamasur-10	40.3bc	99de	12.47e	154.7c	1.58c	1.67de	4.07g	31.64f
Binamasur-5	36.8cd	103c	13.10de	136.9d	1.63b	2.17a	5.02ef	36.32b
Binamasur-7	45.9a	96e	16.65ab	192.8b	1.65ab	2.09ab	6.93b	39.62ab
Binamasur-3	41.6b	109a	13.25de	160.5c	1.59c	1.80d	4.57f	32.49de
Binamasur-9	45.5a	101cd	13.64d	194.2b	1.61bc	1.91c	5.74cd	40.08a
Binamasur-6	45.3a	103c	12.92e	115.9e	1.72a	2.18a	4.53f	33.06d
Binamasur-8	31.3d	96e	17.13a	215.0a	1.69a	1.99b	7.51a	42.42a
CV (%)	13.24	1.88	10.11	14.42	3.25	1.98b	8.90	8.41

Same letter (s) in a column indicates do not differ significantly at P≤ 0.05

Table 3. Flowering pattern at five-day interval of ten lentil varieties during winter season of 2018-19

Varieties	Days to flowering	Number of opened flowers at 3 days interval								Total flowers plant^{-1} (no)
		Days after flowering start								
		0-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24	
Binamasur-2	50c	07.0g	29.3i	49.3f	73.0b	54.7a	36.7a	28.3a	4.6	283d
Binamasur-3	48d	52.6a	122b	143b	63.7d	20.7f	3.30d	0	0	405ab
Binamasur-4	55ab	17.5e	68.5f	72.2e	68.4bc	27.7e	20.6b	12.0b	0	287d
Binamasur-5	50c	36.3c	89.3e	103d	45.3g	17.0fg	0	0	0	291d
Binamasur-6	50c	10.5g	41.0h	71.5e	62.7de	39.0bc	9.6c	0	0	234e
Binamasur-7	53b	12.5f	48.5g	72.0e	48.5fg	37.0cd	18.0b	0	0	237e
Binamasur-8	49cd	42.0b	95.0e	104d	61.7de	32.3d	0	0	0	335c
Binamasur-9	56a	30.5d	130a	156a	64.0cd	14.3g	0	0	0	395b
Binamasur-10	51c	44.7b	112c	129c	51.0f	17.0fg	0	0	0	354c
BARI Masur-4	56a	32.5cd	102d	134c	106a	44.0b	0	0	0	419a
CV (%)	1.56	11.18	10.90	13.18	16.45	15.48	19.6	21.54	--	15.48

Same letter (s) in a column indicates do not differ significantly at P≤ 0.05

Table 4. Variation in reproductive efficiency, days to maturity, biological yield, yield attributes and seed yield of 10 lentil varieties during winter season of 2018-19

Varieties	Reproductive efficiency(%)	Days to maturity	Biological yield (g plant^{-1})	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	100-seed weight (g)	Seed weight plant^{-1} (g)	Harvest Index (%)
Binamasur-2	57.2b	106c	11.4a	162	1.70b	2.70cd	3.80d	33.33e
Binamasur-3	42.7e	110b	9.87c	173bc	1.83a	2.17g	3.43e	34.75e
Binamasur-4	54.7b	116a	8.87ef	157d	1.73b	2.30f	3.29ef	37.10cd
Binamasur-5	53.3b	99ef	10.2b	175b	1.83a	2.50e	4.40b	43.14b
Binamasur-6	49.6cd	103d	8.63f	116g	1.80a	2.60d	3.10f	35.92de
Binamasur-7	75.5a	96f	9.23de	179b	1.87a	3.01a	4.10cd	44.42b
Binamasur-8	48.7d	109b	8.90e	163cd	1.80a	2.87b	4.20bc	47.19a
Binamasur-9	33.7f	101e	7.40h	133f	1.77ab	2.50e	3.20f	43.24b
Binamasur-10	40.1e	103d	8.13g	142e	1.77ab	2.57de	3.87d	47.60a
BARI Masur-4	53.0bc	106c	10.1bc	222a	1.75ab	2.80bc	4.90a	48.51a
CV (%)	12.74	1.58	9.61	11.60	2.85ab	1.98b	6.99	8.72

Same letter(s) in a column do not differ significantly at P≤ 0.05

Table 5. Flowering pattern at 3 days interval of lentil genotypes during winter season of 2019-20

Varieties	Days to flowering	No of opened flowers at 3 days interval								Total flowers plant^{-1}(no.)
		Days after flowering start								
		0-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24	
LMM-4	49b	25cde	94a	151cd	99f	82c	78c	31cd	15b	557e
LMM-6	50b	29b	84c	161a	112d	71d	81b	42b	21a	595b
LMM-9	52b	24cdef	82cd	153c	137b	85b	90a	31cd	11c	599b
LMM-7	51b	27c	79e	141e	121c	97a	77c	32c	9d	585c
LMMI3	50b	26cd	86b	160ab	153a	87b	82b	21e	3e	605a
Binamasur-8	54a	34a	84c	150cd	110de	71d	75d	47a	4e	572cd

Same letter(s) in a column do not differ significantly at P≤ 0.05

Table 6. Variation in reproductive efficiency, days to maturity, biological yield, yield attributes and seed yield of lentil genotypes during winter season of 2019-20

Varieties	Reproductive efficiency (%)	Days to maturity	Biological yield plant^{-1} (g)	Pods plant^{-1}(no.)	Seeds pod^{-1}(no.)	100-seed wt. (g)	Seed wt. plant^{-1} (g)	Harvest Index (%)
LMM-4	39.32d	94.10e	17.23de	252de	1.94de	2.01c	6.98bc	40.51b
LMM-6	42.54a	95.21bcd	19.21a	259bc	2.05bc	2.32bc	6.89bc	35.86de
LMM-9	41.20b	95.10bcd	17.31de	263b	1.97d	1.98cd	6.87bcd	38.70cd
LMM-7	40.02bc	97.23b	18.32bc	271a	2.13ab	2.58b	7.32a	39.95c
LMMI3	38.54de	96.10bc	17.43d	256bcd	2.16a	2.68a	7.34a	42.11a
Binamosur-8	33.2f	102.21a	18.45b	235f	1.79ef	1.99cd	6.21e	33.65f

Same letter(s) in a column do not differ significantly atP<0.05

Table 7. Relationship of flower number, flowering duration and reproductive efficiency with yield and yield attributes of lentil varieties grown in winter season of 2017-18

Characters	Flowers plant^{-1}	Reproductive Efficiency	Biological yield plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	100-seed wt.	Yield plant^{-1}
Flowering duration	0.15	-0.19	0.06	0.08	-0.27	0.05	0.06
Flowers plant^{-1}		-0.58	0.75*	0.79**	0.18	0.23	0.74*
Reproductive Efficiency			-0.17	0.01	-0.10	-0.19	-0.19
Biological yieldplant^{-1}				0.79**	0.49	-0.05	0.88**
Pods plant^{-1}					0.09	0.29	0.75*
Seeds pods^{-1}						0.21	0.39
100-seed wt.							0.21

Table 8. Relationship of flower number, flowering duration and reproductive efficiency with yield and yield attributes of lentil varieties grown in winter season of 2018-19

Characters	Flowers plant^{-1}	Reproductive Efficiency	Biological yield plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	100-seed wt.	Yield plant^{-1}
Flowering duration	-0.46	0.39	0.51	-0.10	-0.46	-0.14	-0.37
Flowers plant^{-1}		-0.65*	-0.12	0.35	-0.18	-0.29	0.20
Reproductive Efficiency			-0.17	0.01	-0.10	-0.19	0.36
Biological yield plant^{-1}				0.79**	0.49	-0.05	0.49
Pods plant^{-1}					0.09	-0.45	0.82**
Seeds pods^{-1}						0.29	0.56
100-seed wt.							0.56

Table 9. Relationship of flower number and reproductive efficiency with yield and yield attributes of lentil genotypes grown in winter season of 2019-20

Characters	Reproductive Efficiency	Biological yield plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	100-seed wt.	Yield plant^{-1}
Flowers plant^{-1}	0.41	0.09	0.46	0.61	0.54	0.39
Reproductive Efficiency		0.2	0.82*	0.62	0.24	0.62
Biological yield plant^{-1}			-0.05	-0.03	0.15	-0.29
Pods plant^{-1}				0.78	0.50	0.81*
Seeds pods^{-1}					0.89*	0.93**
100-seed wt.						0.76

CONCLUSION

Number of total flowers, reproductive efficiency and biological yield of lentil varieties/mutants had no direct relation with seed yield and those had positive correlation with other parameters correlated with seed yield. But these relationships did not equally exist in three years and no relationship was found between flowering duration and yield. Relationship was not also found between pods plant^{-1}, seeds pod^{-1} and 100-seed weight.

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