Effect of different environmental condition on phenology and yield of common bean landraces

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Abstract- A research was conducted at three different altitudes and different environmental conditions i.e. Swat, Peshawar and Bannu. Eight common bean landraces i.e. CB-1, CB-2, CB-3, CB-4, CB-5, CB-6, CB-7, CB-8 were used. These common bean landraces were sown during 2017-2018 and 2018-2019. These landraces of common beans were collected from different mountains of Khyber Pakhtunkhwa Province of Pakistan. These landraces was sown in three diverse environments (Swat, Peshawar and Bannu) of Khyber Pakhtunkhwa. Swat lies in Northern part of Khyber Pakhtunkhwa with altitude 985 m, Peshawar (320m) and Bannu (359m) . Plot size of 3m x 2m was used each consisting of five rows with row to row distance of 50 cm and plant to plant distance was 10cm. The Randomized Complete Block Design (RCBD) was used with three replications. The basal dose of nitrogen (Urea 25 $Kgha^{-1}$) and phosphorous (60 $Kgha^{-1}$) was applied at time of sowing. The land race CB-5 resulted in highest days to emergence (21.50 days), days to flowering (54.83 days), days to pod initiation (63.33 days), days to pod elongation (69.56 days), days to seed initiation (72.1 days), days to full seed formation (83.67 days) and days to full maturity (108.44 days) as compared to CB-1. The landraces sown in Swat had early emergence, flowering, pod initiation, pod elongation, seed initiation, full seed formation and full maturity as compared with Peshawar and Bannu. The landraces sown in 2017 showed minimum days to emergence, days to flowering, days to pod initiation, days to pod elongation, days to seed initiation, days to full seed formation and days to full maturity as compared with landraces sown in 2018. It is concluded that CB-1 had early emergence, flowering, pod elongation, seed initiation, full seed formation and maturity under Swat environmental conditions in the first experiment. Hence, sowing of CB-1 under the environmental condition of Swat is recommended.

Keywords: common bean; environments; reproductive stages;

I. INTRODUCTION

A landrace is a local standardized breed variety of domesticated plant species which is developed by natural process from wild species. Landraces are adopted to the local environment batterly. These landraces are of low cast and show better resistance to various diseases, as some of the pulses needs least use of fertilizers (Merly *et al.*, 2012). Among legumes common bean is the second most using by the people of Pakistan. Common bean is commonly grown in the northern areas of Khyber Pakhtunkhwa. Common bean (*Phaseolus vulgaris* L.) which is also stated as dry bean belonging to the genus *Phaseolus* and have large pinnately trifoliate leaves (Demelash, 2018). The common bean is a self-pollinated plant but cross pollination may occur when the extended stigma of the plant contact with pollen coated insect. Seeds of the common bean are non-endospermic. Generally the common bean does not tolerate low temperature (frost) at any stage of growth and regarded as a warm season crop (Alghamdi and Ali, 2004). Though high temperature does not affect the plant however during high temperature the plant need sufficient amount of water. High temperature at night inhibit the process of pollination (Katungi *et al*., 2009).

Most of the legumes are considered as a rich source of minerals and protein (Moraghon and Grafton, 2001), dietary fiber and some and vitamins but among these common bean is of prime importance. Common bean is a mean of several phytochemicals having health potentials such as polyphenolic compounds, fibers, trypsin inhibitors and lectins (Cardador *et al*., 2002; Camacho *et al*., 2006). Common bean (*Phaseolus vulgaris* L.) plays a key role to minimize intensity of various diseases like diabetes, obesity, cancer and cardiovascular diseases (Ganesan and Baojunxu, 2017).

In Pakistan common bean is one of the most consuming legume. Pakistan depend on other countries to fulfill their domestic needs of common beans and thus spent hundreds of millions of foreign exchange. In Pakistan common bean are only grown in Northern hilly areas. In order to reduce food security it is needed to promote the common bean farming in other regions mainly in plain areas of Pakistan. Identification of high yielding landraces in plain areas of Pakistan not only save the foreign exchange on one hand but it also lead us to self-sufficiency on the other, while enhancing the living standard of our farmers (Amanullah *et al*., 2006). Therefore difference landraces of common bean tested in different regions of KP to select appropriate landrace and suitable region for common bean adaptability and production.

II. MATERIALS AND METHODS

Different landraces of common beans with eight varieties were collected from Northern areas. These landraces were sown under three environments (Swat, Peshawar and Bannu) of Khyber Pakhtunkhwa. Plot size of 3m x 2m was used each consisting of five rows. The Randomized Complete Block Design (RCBD) was applied with three replication. Seeds were sown at 5 cm depth with 10 cm apart. The basal dose of nitrogen (Urea 25 kg ha^{-1}) and phosphorous (60 kg ha^{-1}) was applied at time of sowing. Annual rainfall is 600-800 mm. Soils of Swat is silty loam to silty clay. Climate is sub humid. Mean monthly rainfall in summer is 10-20 mm and 25-75 mm in winter. Peshawar lies in central part of Khyber Pakhtunkhwa. In Peshawar annual rainfall is 450-750 mm. soils are silty clay to clay loam. The mean minimum temperature during the coldest month is 4 °C (39 °F), while the maximum is 18.3 °C (64.9 °F), while in summer mean maximum temperature surpasses 40 °C (104 °F) during the hottest month, and the mean minimum

temperature is 25 °C (77 °F). Climate is sub-tropical to sub-humid. Fields are canal irrigated. Bannu lies in Southern part of Khyber Pakhtunkhwa. Annual rainfall is 300-500 mm. Climate is Semi-Arid. Mean monthly rainfall is 85 mm in summer and 30-45 mm in winter. The following parameters were studied during research.

Procedure for data collection

Days to emergence was taken by calculating days from seeding till 50% of seeds appearance in each sub plot. Data on flower initiation was noted by counting days from sowing till when the plant is ready to set flower in each sub plot. Data on pod initiation was recorded by counting days from sowing till when the plant shows the 1st pod formation in each sub plot. Data on full pod elongation was recorded by counting days from sowing till when the plant set the full pod elongation in each sub plot. Data on seed initiation was recorded by counting days from sowing till when the seed formation occur in pods in each sub plot. Data on full seed formation was recorded by counting days from sowing till when the plant produce the full seed in pods in each sub plot. Days to full maturity was noted by calculating days from seeding till when 50% plants is turned yellow in each sub plot.

Statistical analysis

The experimental layout was Randomized Complete Block Design (RCBD). Means was subjected to least significant difference test (LSD) using statistics 8.1 software.

III. RESULTS AND DISCUSSION

Days to emergence

The mean values of the data regarding days to emergence was significantly affected by years, environmental conditions and common bean landraces (Table-1). The year-I showed early emergence (19.94 days) as compared to year-II (20.58 days). This might be due to environmental variations in meteorological parameters that effect plant growth. More days to emergence was observed in Bannu (21.68days) followed by Peshawar (20.65days) and Swat (18.46 days).). More days to emergence were observed in Bannu while fewer days to emergence were recorded in Swat. This might be due to lower altitude of Bannu as compared to Swat because solar radiations are stronger in Swat which resulted in quick emergence and decreased days in common bean. Singh *et al*., 1994 concluded that if there is exposure of common bean to very low temperature during its active growth stages then the speed of growth and development slows down due to which crop absorbs more solar radiation and consume less for metabolism. Among different common bean landraces late emergence (20.33days) was observed by CB-5, followed by CB-6 (21.06days) and CB-7 (20.58 days). Possible reason for variation in days in common bean may be attributed to variation in growing environment. Early flowering, pod initiation and maturity indicate adoptability of germplasm in a new set of environment which might have resulted early termination of vegetative phase and initiation of reproductive phase in the prevailing favorable environment as compared to germplasm which took longer time to flowering, pod initiation and maturity indicating less adoptability in the prevailing environment. The interaction between environmental conditions vs landraces showed significant effect on days to emergence. Late emergence (23 days) was recorded in CB-5 at Peshawar (Fig-1)

Days to flowering

The mean value given in the table-1 pertaining to this parameter showed a significant effect on environmental conditions, common bean landraces. Whereas years have a non-significant effect on days to flowering. Early flowering was found in year-I (51.33days), while late (51.56 days) was found in year-II. Common bean landraces sown in the first year of an experiment resulted in early days as compared with the second year. It might be due to variability in weather conditions that affect days to flowering. More flowering was found in Bannu (54.85 days), however early flowering (47.47 days) was recorded in swat. Saidon and Schaalje (1993), and Nienhuis and Singh (1986) and Sills and Nienhuis (1993) reported that differences in climatic conditions of different environments directly affect days to flowering of common bean. Common bean CB-5 took more days to flowering (54.83 days), followed by the CB-8 (52.94) and CB-7 (52.50 days). Days varies depending on landraces and environmental conditions in common bean (Adams *et al*., 1985; Wallace et al., 1991). Accumulation of more synthates in less time that favored induction of early flowering and fruiting due to the genetic make-up of the varieties of common bean (Mohan *et al*., 2009). These results are in agreement with results obtained by Rodino *et al*., (2001). The EC× L have a significant effect on days to flowering. Early days to flowering (44 days) was recorded in CB-1 when at Swat, while CB-8 showed late flowering (59.67 days) at Bannu (Fig-2).

Days to pod initiation

The table-1 showed mean values of this parameter. Days to pod initiation was significantly affected by all the three factors i.e. environmental conditions, common bean landraces and years. The more days to pod initiation (61.27 days) was seen in year-1 whereas minimum in year-II (62.79 days). Results indicated that there was significant effect of climate in relation to pod initiation in common bean landraces. These results are in agreement with the findings of Yoshinda (1981). Similarly, Das (2005) reported considerable variability of traits in days. Early pod initiation occurred in Swat (57.93 days) while late pod initiation was found in Bannu (64.02 days). This might be due to favorable environmental conditions and maximum solar radiations in Swat region as compared with Bannu and Peshawar. Late pod initiation was observed in CB-2 (63.33 days) and CB-5 (63.33days) followed by landrace CB-7 (62.94 days). Differences in days to pod initiation in varieties might be due to genetic variation among common bean varieties. The difference for days also could be due to photoperiod, because different varieties respond differently to a particular photoperiod. Ellis *et al*., (1994) reported that in some of the genotypes of common bean the rate of progress towards flowering and pods was affected by temperature and photoperiod. The interaction between environmental conditions vs landraces showed significant effect on pod initiation. Landrace CB-2 took more days to pod initiation (66.17 days) when sown in Bannu (Fig-3).

Days to full pod elongation

The mean value for this characters are given in Table-1 showed significantly affected by years, environmental conditions and common bean landraces. Early pod elongation was shown by the year-I (66.68 days), while late pod elongation was shown by the year-II (69.25 days). This might be due to variation in precipitation in both experimental years. Early pod elongation

was recorded in Swat (64.70 days) and late pod elongation was recorded in Bannu (70.75 days). This might be due to lower altitude of Bannu as compared to Swat because solar radiations are stronger in Swat which resulted in quick emergence and decreased days in common bean. Singh *et al*., 1994 concluded that if there is exposure of common bean to very low temperature during its active growth stages then the speed of growth and development slows down due to which crop absorbs more solar radiation and consume less for metabolism. Similarly more days to pod elongation was taken by the landrace CB-2 (69.83days) followed by CB-6 and CB-7 (69.56 days). A significant effect was shown between environmental conditions and Landraces. Varieties differences might be due to genetic variation among common bean varieties. The difference for days also could be due to photoperiod, because different varieties respond differently to a particular photoperiod. Ellis *et al*., (1994) reported that in some of the genotypes of common bean the rate of progress towards pod elongation was affected by temperature and photoperiod. The landraces CB-2 showed late pod elongation (74.17 days) when sown in Bannu (Fig-4).

Days to seed initiation

Mean values given in Table-1 obtained after analysis of variance of the data for days to seed initiation showed significant affect by environmental conditions, common bean landraces and years. The table showed that year-I had early seed initiation (68.94 days) as compared to year-II (72.76 days). Saidon and Schaalje (1993), and Nienhuis and Singh (1986) and Sills and Nienhuis (1993) reported that differences in climatic condition directly affect the growth habit of common bean. Early seed formation occurred in Swat (68.45 days) while late seed initiation (72.75 days) occurred in Bannu. Early initiation of seed observed in Swat region might be due to favourable environmental conditions and maximum solar radiations. Hosfield*et al*., (1984) noted similar results for days to seed initiation in common bean with their environmental conditions. Similarly late seed initiation was observed in CB-2 (72.78 days) whereas early in landraces CB-6 (72.11 days) and CB-7 (72.17 days). Differences in days to seed initiation was reported by Sawant (1994) and Ram *et al*., (1994). Amini *et al*., (2002) reported the same results regarding variation in days to initiation in common bean landraces. The interaction between environmental conditions vs landraces showed significant effect on days to seed initiation. Among interaction between landraces and environmental conditions maximum days to seed initiation was recorded in CB-2 (74.50 days) at Bannu (Fig-5).

Days to full seed formation

Data recorded on the days to full seed formation are presented in Table-1. Days to full seed formation was significantly affected by environmental conditions, common bean landraces and years. Early full formation occurred in year-I (77.19 days) while late seed formation occurred in year-II (85.43 days). Differences in days within years might be due to differences in temperature, rainfall, humid, wind, solar radiation and soil conditions. Late seed formation was observed in Bannu (85.31 days) whereas early in Swat (76.79 days). This might be due to lower altitude of Bannu as compared to Swat because solar radiations are stronger in Swat which resulted in quick seed formation. Singh *et al*., 1994 reported the same results regarding days to full seed formation. Common bean landrace CB-7 (83.67 days) took more days to seed formation, followed by CB-6 (82.78 days) and CB-5 (82.22 days). Differences in days regarding varieties might be due to genetic variation among common bean landraces. Ellis *et al*., (1994) said that the difference for days also could be due to photoperiod, because different varieties respond differently to a particular photoperiod. The interaction between environmental condition and landraces have a significant effect on days to full seed formation. Among landraces and environmental condition late seed formation was recorded in CB-7 (87.67 days) when sown in Bannu (Fig-6).

Days to full maturity

Mean values given in table-2 obtained after analysis of variance of the data for days to full maturity showed significant affect by environmental conditions, common bean landraces and years. The table showed that early full maturity occurred in year-I (104.32 days) as compared to year-II (110.40 days). This might be due to favourable environmental conditions in the second experiment. Maximum days to maturity was reported in Bannu (113.06 days) followed by Peshawar (107.67 days) and Swat (101.35 days). This might be due to lower altitude of Bannu as compared to Swat because solar radiations are stronger in Swat which resulted in quick maturity and decreased days in common bean. Singh *et al*., (1994) reported the same results regarding days to maturity. Similarly CB-6 took more days to maturity (108.44 days) followed by CB-8 (108.06 days) while early maturity (106.72 days) was investigated in CB-1. The variation among genotypes was influenced by the genetic constitution of the individuals. There was genetic variability among the common bean landraces. These results are in agreement with the findings of Yoshinda (1981). The EC× V have a significant effect on days to full maturity. The CB-6 took114.50 days to reach the maturity when sown in Bannu (Fig-7).

Seed Yield (kg ha^{-1})

Years, environmental conditions and landraces showed a significant affect on seed yield kg ha^{-1} (table-2). The year-I showed more seed yield (7443.1 kg ha^{-1}) as compared to year-II (6348.9 kg ha^{-1}). Maximum seed yield was recorded in Swat (14158 kg ha^{-1}) followed by Peshawar (4064.2 kg ha^{-1}) and Bannu (2765.5 kg ha^{-1}). Ambachew *et al*., (2015) reported that yield reductions were attributed to unsuccessful flower fertilization which is an important consideration for determining seed yield under much hot condition. Among different common bean landraces maximum seed yield was found in CB-1 (10682.28 kg ha^{-1}), followed by CB-6 (9570.44 kg ha^{-1}) and CB-8 (7335.06 kg/ha). The interaction between environmental conditions vs landraces showed nonsignificant effect on seed yield however, maximum seed yield (23234.5 kg ha^{-1}) was recorded in CB-1 when sown in Swat as compared to the rest of regions. (Fig-13). However, Emam, (1985) and Emam and Sabaghpour (2003) stated that common bean grain yield was significantly reduced when moisture stress occurs during the reproductive phase. Reduction in grain yield and biological yield was caused by reduction in the yield components because the seed yield is the product of several yield components and these components are generally the product of sequential development processes. Any reduction in biological and grain yield directly reduces grain yield (Ardakani *et al*., 2013). Therefore, a reduction in yield is largely due to reduction in grain yield. The reduction in grain yield is attributed to lower percentage of pod

production when the moisture stress occurs during flowering (Emam, 1985) and from embryos abortion when the moisture stress occurs during pod filling stage (Robins and Domingo, 1956). Ardakani *et al*., (2013) noted that water stressful and hot climatic conditions reduces yield. Boutraa *et al*., (2001) reported that seed yield reduction of up to 60 % observed in common beans under drought stress areas was attributed to losses of 63.3 % in pods plant^{-1}, 28.9 % in seed pod^{-1} and 22.3 % in seed weight plant^{-1}. This statement is also in agreement with that obtained by Castaneda *et al*., (2009) hot and drought areas resulted in low seed yield. He said that under hotter conditions, the regular process of pollen formation may alters due to which they don't get chance to pollinate properly. Swat resulted in higher yield and yield components. Results indicated that favourable environmental conditions affected plants by improving weight of pods and thus increased seed yield. Due to this reason, common bean may have full pods and hence are heavier compared to common beans grown under an unfavourable environment. Alghamdi (2007) concluded that environmental condition significantly affected the performance of common bean landraces, Salehi *et al*., (2008) also found significant and positive correlations between number of seeds pod^{-1}, number of pods plant^{-1} and pod length with grain yield. Moreover grain filling occurs when the environment temperature is very high and overheating prevents grain filling process and consequently the rate of stored metabolic materials will decrease as the respiration increases. As a result, they produce small pods with little weight and thus reduce seed yield (Aliloo, 2003). Maximum biological and grain yield was noted CB-1 as compared with the rest of common bean varieties. The reason might be due to genetic variation among common bean landraces that clearly gave significant affect. The results obtained in our investigations were found to be similar with those found by Babar et al. (2002), Ramgry *et al*., (1989) and Kumar *et al*., (1993). The most probable reason for pods variability might be due to their genetic variation among varieties as reported by Fageria *et al*., (2002). Lopez *et al*., (1996) reported that total number of flowers in some susceptible varieties may be reduced up to 47% under too hot conditions thereby influencing the number of pods per plant; though pod setting may also vary among different common bean varieties. Different types of common bean landraces showed differences in yield and yield components. Çiftçi and Fehirali (1984) reported that the different landraces of common bean responded differently among yield and yield components. Yield variation could be due to the genetic variability of different landraces. Hassan et al. (1995) reported high heritability for yield and yield components. Grain yield showed positive association with pod plant^{-1} (Amanullah and Hatam, 2000; Ahmad *et al*., 2000; Amanullah *et al*., 2000; Thiyagarajan and Rajasekaran, 1993; Muhammad *et al*., 1994; Ram et al., 1994; Sawant, 1994), hundred seeds weight (Amanullah and Hatam, 2000; Ahmad et al., 2000; Amanullah *et al*., 2000, Thiyagarajan and Rajasekaran, 1993; Sawant, 1994) and seed yield (Amanullah and Hatam, 2000; Ahmad *et al*., 2000; Amanullah *et al*., 2000).

Biological Yield (kg ha^{-1})

The table showed that landraces are significantly affected by environmental conditions, common bean landraces except years (table-2). The year-I showed more biological yield (10744kg ha^{-1}) than year-II (10362 kg ha^{-1}). Maximum biological yield was investigated in Swat (18757 kg ha^{-1}) followed by Peshawar (7234 kg ha^{-1}) and Bannu (5669 kg ha^{-1}). Similarly maximum biological yield was found in CB-1 (15369 kg ha^{-1}), followed by CB-8 (14422 kg ha^{-1}) and CB-7 (10911 kg/ha). The interaction between environmental conditions vs landraces showed significant effect on biological yield however, CB-1 showed maximum biological yield (31023 kg ha^{-1}) at Swat (Fig-14). Common bean to moisture stress during the reproductive stage reduced grain yield. Tropical regions affected significantly seeds pod^{-1} and pods plant^{-1}. Emam *et al*., (2010) reported that tropical and drought areas reduces yield through decreasing leaf area and accelerating leaf senescence and plant death. This might be due to less water availablility which affect all developmental stages and thus reduce biological yield (Beshir *et al*., 2016). Confalone *et al*., (2009) reported that the biological yield constitute the main yield component which is mostly affected by environmental conditions. Andrade *et al*., (2002) found drought condition is also responsible for permanent declination of yield in common bean.

IV. CONCLUSION

Among different locations Swat had early emergence, flowering, pod imitation, days to pod elongation, seed imitation, full seed formation, physiological maturity, full maturity, seed yield and biological yield. Among different landraces CB-1 have early days to emergence, days to flowering, days to pod imitation, days to pod elongation, days to seed imitation, seed formation, maturity, pods plant^{-1}, hundred seed weight, seed yield, biological yield, whereas CB-5 had maximum days to emergence, days to flowering, and days to pod imitation. Common bean landraces sown in 2017 had minimum days to emergence, days to flowering, days to pod imitation, days to pod elongation, days to seed imitation, days to full seed formation, days to physiological maturity, days to full maturity, maximum seed yield, and biological yield as compared to 2018. Among interactions between locations vs landraces, the landrace CB-1 had early days to emergence, flowering, pod imitation, pod elongation, seed imitation, full seed formation, seed yield and biological yield when sown in Swat. While landrace CB-2 had maximum days to physiological maturity and CB-6 had maximum days to full maturity. The following recommendations are made in the light of conclusions. It is recommended that CB-1 showed early reproductive stages and highest yield in all the environmental conditions.

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Table. 1. Days to emergence, days to flowering, and days to pod initiation as affected by different environmental conditions, common bean landraces and years.

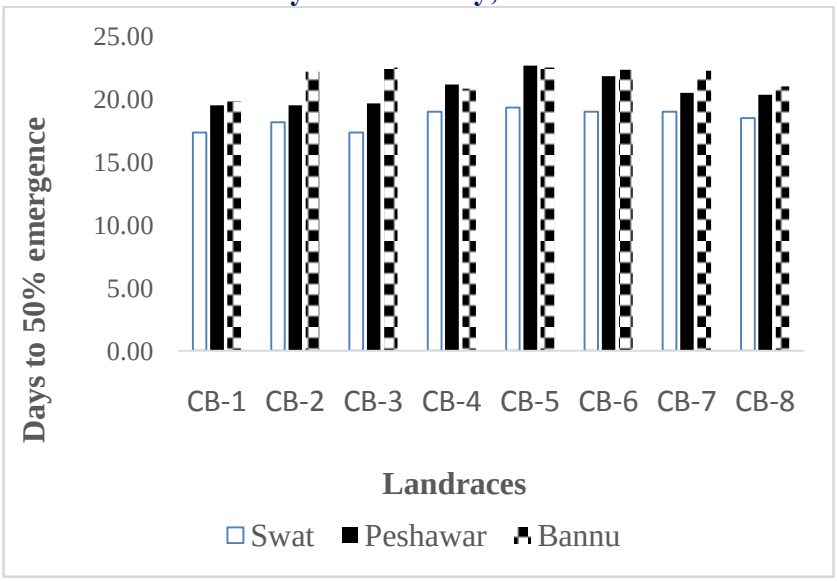
	Land races								
Days to emergence	**Locations**	CB-1	CB-2	CB-3	CB-4	CB-5	CB-6	CB-7	CB-8	**Means**
	Swat	17.33	18.17	17.33	19	19.33	19	19	18.50	18.46c
	Peshawar	19.5	19.5	19.66	21.16	22.66	21.83	2.5	2.33	20.65b
	Bannu	19.83	22.17	22.5	20.83	22.50	22.33	22.25	21	21.68a
	Means	18.89d	19.94c	19.83c	20.33bc	21.50a	21. 06ab	20.58bc	19.94c	
	Year-I	19.94	Year-II	20.58						
	LSD (0.05)	Years (Y)	Locations (LC)	Landrace (L)	L* LC	L*Y	LC *Y	L* LC *Y		
	Value	0.3950	0..4838	1.3684	1.1173	1.1173	0.6842	1.9352		
Days to flowering	**Locations**	CB-1	CB-2	CB-3	CB-4	CB-5	CB-6	CB-7	CB-8	**Means**
	Swat	44.33	48	46.17	48	51.50	46.83	47.33	47.67	47.47c
	Peshawar	49.33	53.17	51	52.50	55.5	51.66	51.50	51.50	52. 02b
	Bannu	50. 00	54.17	52	54.67	57.50	52.17	58.67	59.67	54.85a
	Means	47.89d	51.78b	49.72c	51.72b	54.83a	50.22c	52.50b	52.94b	
	Year-I	51.33a	Year-II	51.56a						
	LSD (0.05)	Years (Y)	Locations (LC)	Landrace (L)	L* LC	L*Y	LC *Y	L* LC *Y		
	Value	0.64	0.79	1.29	2.23	1.82	1.11	3.16		
Days to pod initiation	**Locations**	CB-1	CB-2	CB-3	CB-4	CB-5	CB-6	CB-7	CB-8	**Means**
	Swat	56.83	58.17	58.33	57.33	59.33	58.17	58.33	57	57.93c
	Peshawar	62.17	65.67	62.83	63	65.66	64.16	65.16	64.50	64.16b
	Bannu	62.33	66.17	62.67	62.33	65. 00	64.67	65.33	63.67	64. 02a
	Means	60.44f	63.33a	61.28de	60.89ef	63.33a	62.33bc	62.94ab	61.72cd	
	Year-I	61.27b	Year-II	62. 02a						
	LSD (0.05)	Years (Y)	Locations (LC)	Landrace (L)	L* LC	L*Y	LC *Y	L* LC *Y		
	Value	0.3214	0.3936	0.6427	1.1133	0.9090	0.5566	1.5744		

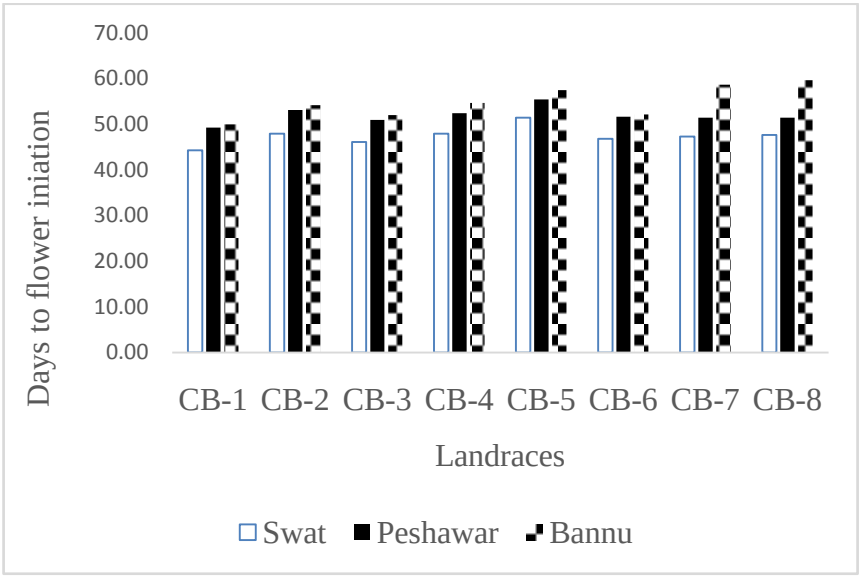
Table. 2. Days to pod elongation, days to seed initiation and days to full seed formation as affected by different environmental conditions, common bean landraces and years.

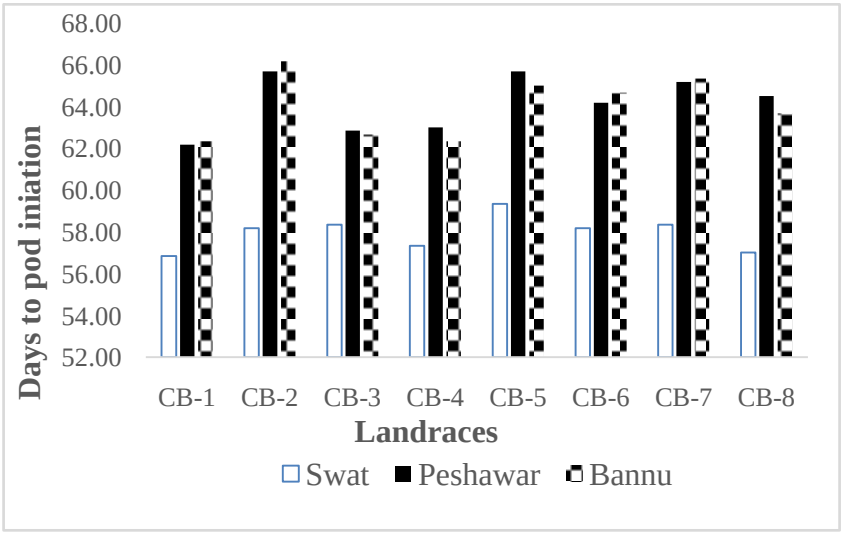
	Land races								
Days to Pod elongation	**Locations**	CB-1	CB-2	CB-3	CB-4	CB-5	CB-6	CB-7	CB-8	Means
	Swat	63.17	65.50	63.50	63.67	65.17	65.67	65.83	65.17	64.70c
	Peshawar	66.33	69.83	67. 00	66.33	69.33	69.83	70. 00	68.83	68.43b
	Bannu	67.50	74.17	68.17	68.50	71.50	73.17	72.83	70.17	70.75a
	Means	65.67c	69.83a	66.22c	66.17c	68.67b	69.56a	69.56a	68. 06b	
	Year-I	66.68b	Year-II	69.25a						
	LSD (0.05)	Years (Y)	Locations (LC)	Landraces (L)	L* LC	L*Y	LC *Y	L* LC *Y		
	Value	0.3250	0.3980	0.6500	1.1257	0.9192	0.5629	1.592		
Days to seed iniation	**Locations**	CB-1	CB-2	CB-3	CB-4	CB-5	CB-6	CB-7	CB-8	Means
	Swat	66.50	70.50	67. 00	67.66	67.50	69.33	70.17	70. 00	68.45c
	Peshawar	69.67	73.33	70.16	69.66	71. 00	72.66	72.50	71.83	71.35b
	Bannu	7.67	74.50	70.50	71.83	72.83	74.33	73.83	73.50	72.75a
	Means	106.72d	107.06d	106.89d	106.89d	107.17cd	108.44a	107.67bc	108.06ab	
	Year-I	68.94b	Year-II	72.76a						
	LSD (0.05)	Years (Y)	Locations (LC)	Landraces (L)	L* LC	L*Y	LC *Y	L* LC *Y		
	Value	0.3725	0.4563	0.7451	1.2905	1.0537	0.6452	1.825		
Days to full seed formation	**Locations**	CB-1	CB-2	CB-3	CB-4	CB-5	CB-6	CB-7	CB-8	Means
	Swat	75.83	76. 00	75.50	76.33	77.67	77.33	78.50	77.17	76.79c
	Peshawar	78.5	81.83	80. 00	81.66	82.83	83.66	84.83	81.33	81.83b
	Bannu	82.67	87. 00	82.5	84.51.1491	86.17	87.33	87.67	84.67	85.31a
	Means	79. 00f	81.61cd	79.33f	80.83e	82.22bc	82.78b	83.67a	81. 06de	
	Year-I	77.19b	Year-II	85.43a						
	LSD (0.05)	Years (Y)	Locations (LC)	Landraces (L)	L* LC	L*Y	LC *Y	L* LC *Y		
	Value	0.3317	0.4063	0.6635	1.1491	0.9383	0.5746	1.6251		

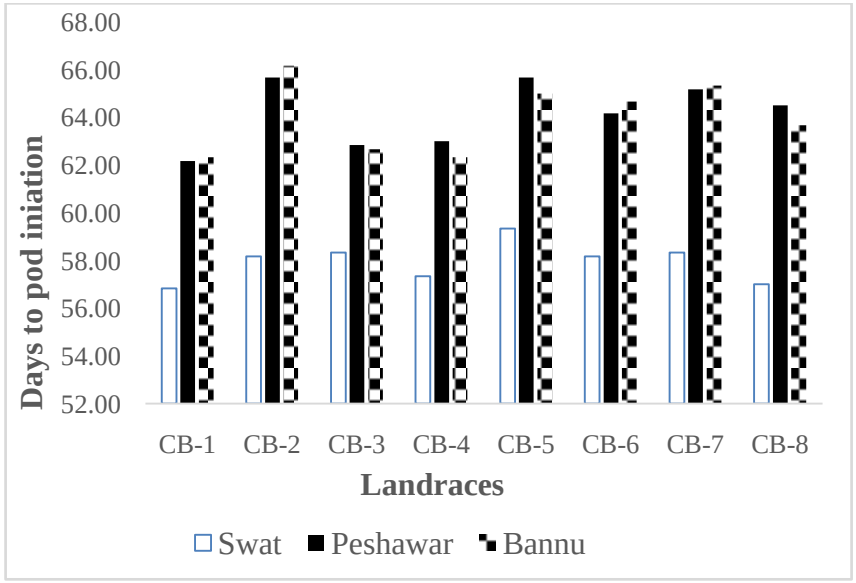
Table. 2. Days to full maturity, seed yield and biological yield as affected by different environmental conditions, common bean landraces and years.

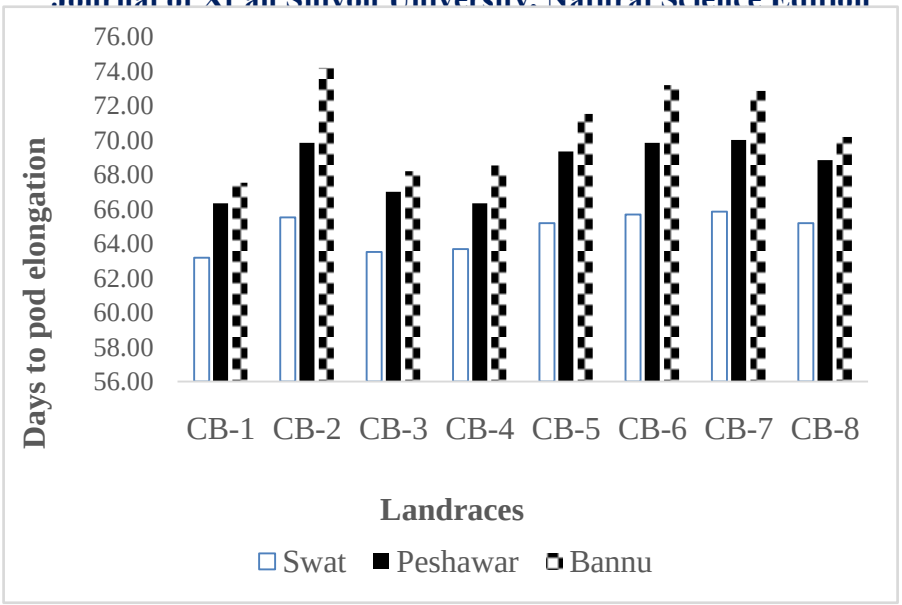
Days to full maturity	**Locations**	CB-1	CB-2	CB-3	CB-4	CB-5	CB-6	CB-7	CB-8	Means
	Swat	101.17	100.33	100.83	101.00	101.33	101.83	102.17	102.17	101.35c
	Peshawar	106.83	107.50	107.50	108.16	107.50	109.00	107.16	107.67	107.67b
	Bannu	112.17	113.33	112.33	111.50	112.67	114.50	113.67	114.33	113.06d
	Means	106.72d	107.06d	106.89d	106.89d	107.17cd	108.44a	107.67bc	108.06ab	
	Year-I	104.32b	Year-II	110.40a						
	LSD (0.05)	Years (Y)	Locations (LC)	Landraces (L)	L* LC	L*Y	LC *Y	L* LC *Y		
	Value	0.2924	0.3581	0.5849	1.0130	0.8271	0.5065	1.4326		
Seed yield	**Locations**	CB-1	CB-2	CB-3	CB-4	CB-5	CB-6	CB-7	CB-8	Means
	Swat	23234.50	10323.83	12848.00	11234.00	7165.83	21205.33	12266.00	14989.67	14158a
	Peshawar	4914.33	3533.00	3755.00	2752.333	2752.333	4446.167	4443.667	4265.83	4064.2b
	Bannu	3898.00	2495.17	2369.83	1906.67	3122.83	3059.83	2522.33	2749.67	2765.5ba
	Means	10682.28a	5450.67b	6324.28ab	5297.67b	4897.44b	9570.44ab	6410.67ab	7335.06ab	
	Year-I	7643.2a	Year-II	6348.9a						
	LSD (0.05)	Years (Y)	Locations (LC)	Landraces (L)	L* LC	L*Y	LC *Y	L* LC *Y		
	Value	2451	3002.6	4903.3	8492.7	6934.3	4246.4	12011		
Biological yield	**Locations**	CB-1	CB-2	CB-3	CB-4	CB-5	CB-6	CB-7	CB-8	Means
	Swat	31022.67	15347.67	18409.33	17144.83	13982.83	13448.67	19667.17	21035.50	18757.33a
	Peshawar	8097.17	6609.83	6924.333	5432.333	7732.333	7882.833	7642.833	7548.50	7233.77b
	Bannu	6987.67	5159.17	4934.67	4342.83	6361.67	6462.67	5422.83	5682.17	5669.21c
	Means	15369.17a	9038.89d	10089.44c	8973.33d	9358.94cd	9264.72d	10910.94b	11422.0b	
	Year-I	10744a	Year-II	10362a						
	LSD (0.05)	Years (Y)	Locations (LC)	Landraces (L)	L* LC	L*Y	LC *Y	L* LC *Y		
	Value	407.68	499.31	815.37	1412.3	1153.1	706.13	1997.2		

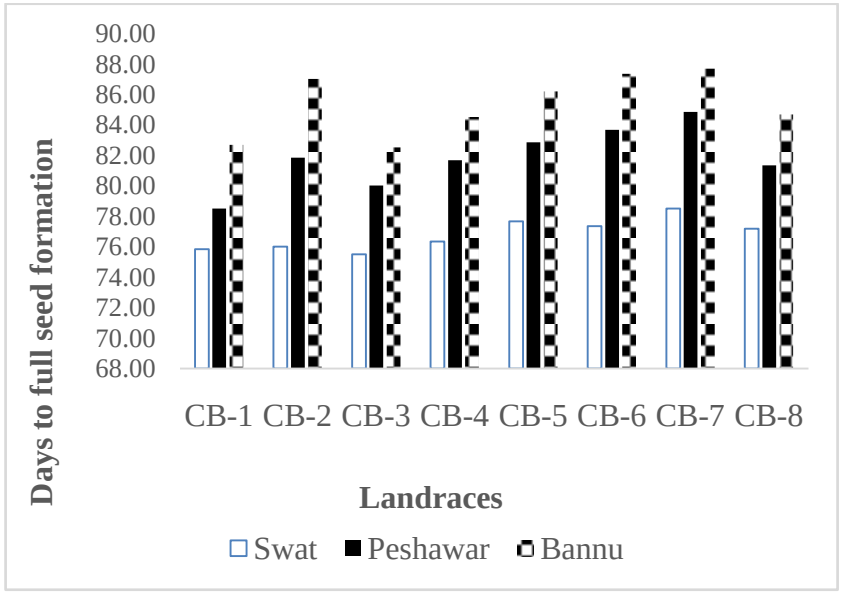

25.00
20.00
15.00
10.00
5.00
0.00
Days to 50% emergence
CB-1 CB-2 CB-3 CB-4 CB-5 CB-6 CB-7 CB-8
Landraces
Swat Peshawar Bannu

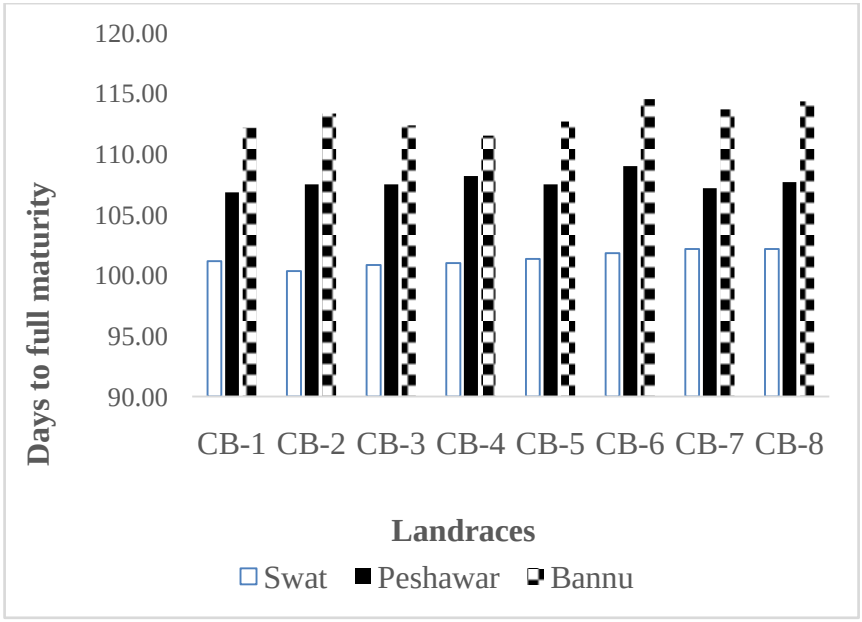

70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Days to flower iniation
CB-1 CB-2 CB-3 CB-4 CB-5 CB-6 CB-7 CB-8
Landraces
Swat Peshawar Bannu


68.00
66.00
64.00
62.00
60.00
58.00
56.00
54.00
52.00
Days to pod iniation
CB-1 CB-2 CB-3 CB-4 CB-5 CB-6 CB-7 CB-8
Landraces
Swat Peshawar Bannu


68.00
66.00
64.00
62.00
60.00
58.00
56.00
54.00
52.00
Days to pod iniation
CB-1 CB-2 CB-3 CB-4 CB-5 CB-6 CB-7 CB-8
Landraces
Swat Peshawar Bannu


76.00
74.00
72.00
70.00
68.00
66.00
64.00
62.00
60.00
58.00
56.00
Days to pod elongation
CB-1 CB-2 CB-3 CB-4 CB-5 CB-6 CB-7 CB-8
Landraces
Swat Peshawar Bannu


90.00
88.00
86.00
84.00
82.00
80.00
78.00
76.00
74.00
72.00
70.00
68.00
Days to full seed formation
CB-1 CB-2 CB-3 CB-4 CB-5 CB-6 CB-7 CB-8
Landraces
Swat Peshawar Bannu


120.00
115.00
110.00
105.00
100.00
95.00
90.00
Days to full maturity
CB-1 CB-2 CB-3 CB-4 CB-5 CB-6 CB-7 CB-8
Landraces
Swat Peshawar Bannu

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