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Assessing agrometeorological indices and physico-chemical attributes for ten blackgram cultivars under new alluvial zone of West Bengal

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ABSTRACT

A trial was directed at the Jaguli Instructional Farm of Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal to evaluate the heat indices of ten blackgram varieties during post-kharif season of 2018. Mean cultivar days from sowing to emergence, flower initiation, pod initiation and maturity of blackgram were found to be 4.93, 42.17, 57.57 and 83.40 days, respectively. Among 10 blackgram varieties, number of days to maturity varied between 81.33 days (V_6) and 84.67 days (V_3 and V_4). The average summed GDD, HTU and PTUs for entire life cycle were recorded as 1339.59°C day, 8542.07°C hour and 15881.29°C hour, respectively. Genetic variation in plant height of blackgram was noted between 25.93 and 30.67 cm at 30 DAS, 32.33 and 41.67 cm at 45 DAS, 44.33 and 52.93 cm at 60 DAS; and 51.10 and 60.27cm at maturity in the study. KU 16-77 (V_8), Pant U 35 (V_3) and Pant U 19 (V_1)gave higher seed yield (1144.81, 1097.22 and 1057.17 kg ha^{-1}). The variation in Heat use efficiency was noted between 0.607 kg ha^{-1}p C day^{-1} (Pant U-31) and 0.852 kg ha^{-1}°C day^{-1} (KU 16-77). In case of protein content in seeds, KU 15-07 (V_5) recorded highest value (24.42%) while KU 15-102 had lowest protein content (19.07%).

Keywords:Agrometeorological indices, black gram, GDD, HTU, PTU, protein content

India is one of the major pulses producing nations in the world having a share of 30-35% and 27-28% of the total area and production of pulses, respectively. In India, around 24 million hectare is under pulse cultivation producing almost 15.9 million tonnes but still falls short of the current utilization of 17.65 million tonnes.To fulfill the expanding need of pulse production, at any rate, 29.30 million tonnes of pulse production is required by 2020 (Ali and Kumar, 2008). But the increase in pulse production has been only marginal and may be microscopic when compared with the phenomenal increase achieved in wheat and rice. With the increasing population in India, the availability of pulses has drastically reduced from 30 gm capita^{-1} day^{-1} during 2002 to around 26 gm capita^{-1} day^{-1} at present, have resulted in 80 million protein deficit malnourished children in the country (FAO, 2004). According to ICARDA (2016), West Bengal produced 61,000 tonnes black gram from 81,000 ha area during 2016 with an average productivity of 753 kg ha^{-1}.

Singh *et al*. (2013) tested six genotypes of blackgram *viz*. Sekhar-2, Pant U-19, Pant U- 31, WBU-109, Mash-364 and Mash-1008 to notice number of days required to complete the four different phenophases *i.e*., vegetative, reproductive, maturity and harvesting at Punjab. From the experiment it was observed that early sown crops took lower agroclimatic indices than the late sown crop and Mash-364 and Mash-1008 found out to be the most promising genotypes.

Patidar (2015) in his experimental trial conducted at Rewa, Madhya Pradesh during *kharif* season of 2015 on 16 black gram cultivars concluded that among all the cultivars, PU-30 achieved earlier days to flower initiation (35.67 days) as well as crop maturity (60.67 days) followed by JU-2 which took 61.67 days to attain maturity. Contrary to this, PU 35 took maximum days (40.33) to flower initiation and maturity (73.67 days). Similarly, Mane *et al*. (2017) reported that blackgram variety TAU-1 matured earlier (70 days) than other two varieties *i.e*., AKU-15 (72 days) and BDU-1 (74 days). Unlikely, mean cultivar period for sowing to emergence, emergence to flower initiation, flower initiation to pod initiation and pod initiation to maturity was found out to be 5, 27, 15 and 25 days, respectively.

The diverse phenophases are dependent upon crop gentotypes and under these contexts several phenological models have been created by utilizing he concepts of developing degree days (GDD), photothermal units (PTU) and Heliothermal units (HTU) (Esfandiary *et al*., 2009).

The legitimate development of a genotype is influenced by the climate where it develops. Consequently, there is an urgent need to discover the ideal season of planting of mungbean for acquiring high return just as opportune development of the crop. Various genotypes may perform contrastingly under different conditions (Singh *et al*., 2017). Along these lines, versatility of a genotype over different conditions should be tested under which it is to be developed.

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MATERIALS AND METHODS

The field test was laid out at Jaguli Instructional Farm (22°93' N, 88°53' E longitude and 9.75 m above mean sea level) of Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India during post-*kharif* period of 2018. The experimental field was on a medium land with assured drainage facilities.

Meteorological features of the experimental site

The farm is situated at New Alluvial Zone of West Bengal under humid sub-tropical climatic region. The entire year can be classified into three distinct seasons viz. pre-*kharif* (March – May) characterized by dry and warm weather, wet and warm *kharif* season (June – October) and dry and cool *rabi* season (November – February). The temperature begin to rise from the end of February and the maximum is reached during April to May. Again, it started to decline from mid-October reaching the minimum about 10^0C by January. The average of annual rainfall was about 1396 mm of which 70–80% occured during rainy season due to south-west monsoon that generally onset in the region during second week of June. The relative humidity was high during *monsoon* months *i.e.*, from July to October. The maximum and minimum temperature during the cropping season period was found to vary between 30.3 and 33.0^0C and 14.0 and 23.0^0C, respectively. The total rainfall received during the investigation period was 350.1 mm; with a monthly range between 0.0 (November) and 202.3 mm (August). The relative humidity ranged between 52.8 to 97.3% during the period of experiment in 2018. The bright sunshine hour was <6 hours in first two months due to more rainy days, but it was >6.5 hours in last two months of the experiment because of less cloudy periods. The monthly average wind speed was found to vary between 1.0 km hour^{-1} and 2.0 km hour^{-1} during the cropping period.

Studying the phenological development

Observations on phenological phases were recorded at 2-3 days interval from sowing to maturity.The different phenophases noted during the study were (i) seedling emergence (when >50% seedlings emerged above the ground), (ii) flower initiation (iii) pod development (when the first pod started to form), (iv) maturity (>80% pods turned black and the seeds in the pods matured).

Input use efficiency

Agro-climatic indices such as growing degree days (GDD), helio-thermal units (HTU), photo-thermal units (PTU), heat use efficiency (HUE) and pheno-thermal index (PTU) were calculated by standard formulae (Nuttonson, 1955).

$GDD = (T_{max} + T_{min})/2 - T_{base}$

where, T_{max} = Daily maximum temperature (^{0}C)

T_{min} = Daily minimum temperature (^{0}C)

T_{base} = Base temperature of 10^0C

Heliothermal units (HTU), the product of GDD and corresponding actual sunshine hours for that day were computed on daily basis as:

HTU= GDD × Actual Sunshine hours (BSS)

Where, BSS = Bright Sunshine hours

Photothermal units (PTU), the product of GDD and corresponding day length for that day were computed regularly as follows:

PTU= GDD × Day Length

Where, Day length refers to maximum possible sunshine hours.

Growing degree-days, heliothermal units and photothermal units were accumulated from the date of sowing to each date of sampling and a particular date of phenophase to give accumulated indices.

Heat use efficiency (HUE)

The Heat Use Efficiency (HUE) is the amount of above ground dry matter which is accumulated per degree day. It has been calculated by using the following formula:

Heat use efficiency (g/m^2/°C day) = Dry Matter Yield/ Grain yield (g/m^2) / AGDD (^{0}C day)

Where, AGDD= Accumulated Growing Degree Days

Protein content

The protein content (%) in seed was determined by modified Kjeldhl's methods. At first total nitrogen of seeds was measured and then it was multiplied by 6.25 to determine the protein contents of the seed samples.

RESULTS AND DISCUSSION

Blackgram has indeterminate type of growth habit consisting of vegetative and reproductive phases being intermingled together for a specific period in the life cycle. In the experiment, four phenophases of blackgram were studied: sowing to emergence, emergence to flower initiation, flower initiation to pod initiation and pod initiation to maturity. Mean cultivar days from sowing to emergence, flower initiation, pod initiation and maturity of blackgram were 4.93, 42.17, 57.57 and 83.40 days, respectively. Varietal differences in phenophasic duration were evident during sowing to emergence (S-E), pod initiation to maturity (PI-M) and life cycle (S-M) in the study. Among 10 varieties tested, KU 14-16 (V_4) took maximum number of days (6.00) to emerge, while Pant U 19 (V_1) required minimum days (4.00) in the investigation. The number of days to maturity of 10 blackgram varieties varied between 81.33 days (V_6) and

Table 1: Phenophesic duration of blackgram varieties during post-*kharif* season

Variety	Phenophase (days)			Lifecycle (days)	
	Sowing to emergence (S -E)	Emergence to flow erinitiation (E-FI)	Flowerinitiation to podinitiation (FI -PI)	Podinitiationto maturity (PI-M)	Sowing to maturity (S-M)
V1	4.00	37.00	15.00	26.67	82.67
V2	5.00	37.33	14.70	26.67	83.67
V3	4.33	38.33	15.30	26.67	84.67
V4	6.00	37.00	16.00	25.67	84.67
V5	5.33	36.67	15.70	25.00	82.67
V6	5.00	36.00	15.00	25.33	81.33
V7	4.67	37.33	16.00	24.67	82.67
V8	5.33	37.33	16.00	24.67	83.33
V9	5.00	37.00	15.30	26.67	84.00
V10	4.67	38.33	15.00	26.33	84.33
SEm (±)	**0.31**	**0.50**	**0.43**	**0.26**	**0.21**
LSD (0.05)	**0.92**	**NS**	**NS**	**0.79**	**0.63**

NS=Not significant, V_1= Pant U 19; V_2= Pant U 31; V_3= Pant U 35; V_4= KU14-16 (Uttara); V_5= KU15-07;V_6=KU15-89 (TU-22), V_7=KU15-102 (IU05-1),V_8=KU16-77 (KPU12-1730), V_9=KU17-64(DBG-11),V_{10}=KU17-80(AKU13-16)

Table 2: Growing degree days at different phenophases of blackgram varieties during post-*kharif* season

Variety	Growing degree days (^{o}Cday)				
	Sowing to emergence (S -E)	Emergence to flower initiation (E-FI)	Flower initiation to pod initiation (FI -PI)	Pod initiation to maturity (PI-M)	Sowing to maturity (S-M)
V_1	72.55	655.60	233.00	369.63	1330.78
V_2	90.00	661.85	226.00	365.63	1343.48
V_3	78.36	679.05	237.00	362.15	1356.57
V_4	108.40	654.98	246.82	346.27	1356.47
V_5	96.13	649.63	242.90	340.67	1329.33
V_6	90.00	638.15	233.00	348.02	1309.17
V_7	84.18	661.87	248.70	336.03	1330.78
V_8	96.45	661.30	252.55	333.33	1343.63
V_9	90.00	656.05	231.85	365.63	1343.53
V10	84.18	679.15	231.15	357.65	1352.13
SEm (±)	**5.46**	**8.75**	**6.93**	**4.53**	**3.04**
LSD (0.05)	**16.35**	**NS**	**NS**	**13.56**	**9.11**

NS=Not significant, V_1= Pant U 19; V_2= Pant U 31; V_3= Pant U 35; V_4= KU14-16 (Uttara); V_5= KU15-07;V_6=KU15-89 (TU-22), V_7=KU15-102 (IU05-1),V_8=KU16-77 (KPU12-1730), V_9=KU17-64(DBG-11),V_{10}=KU17-80(AKU13-16)

84.67 days (V_3 and V_4) (Table 1). Thus, all the cultivars were more or less of the same duration and the differences in growth duration was mainly due to significant variation in phenophases.

Growing degree days (GDD)

Mean cultivar GDD from sowing to emergence, flower initiation, pod initiation and maturity of blackgram were 89.03, 748.79, 987.09 and 1339.59^{0}C day, respectively (Table 2). All the ten blackgram varieties differed significantly for accumulated GDD at all the phenophases excluding emergence to flower initiation (E-FI) and flower initiation to pod initiation (FI-PI) in the investigation. The growing degree days for entire life cycle varied between 1309.17^{0}C day (V_6) and 1356.57^{0}C day (V_3) which may be due to the length

Table 3: Helio-thermal units at different phenophases of blackgram varieties during post-*kharif* season

Variety	Heliothermal units(°Chour)				
	Sowing to emergence (S -E)	Emergence to flower initiation (E-FI)	Flower initiation to pod initiation (FI -PI)	Pod initiation to maturity (PI-M)	Sowing to maturity (S-M)
V_1	368.72	3888.52	1570.19	2654.37	8481.80
V_2	440.09	3982.15	1497.48	2613.92	8533.63
V_3	403.62	4099.92	1602.85	2563.64	8670.03
V_4	627.98	3927.52	1680.67	2473.86	8710.03
V_5	524.94	3881.43	1641.05	2434.52	8481.94
V_6	473.42	3783.82	1570.19	2450.29	8277.72
V_7	438.52	3969.08	1698.79	2375.55	8481.94
V_8	541.56	3961.98	1732.63	2347.55	8583.72
V_9	473.42	3934.18	1545.45	2613.92	8566.97
V_{10}	438.52	4112.99	1554.88	2526.54	8632.93
SEm (±)	**40.17**	**69.74**	**57.85**	**34.74**	**19.01**
LSD (0.05)	**120.27**	**NS**	**NS**	**104.00**	**56.91**

NS=Not significant, V_1= Pant U 19; V_2= Pant U 31; V_3= Pant U 35; V_4= KU14-16 (Uttara); V_5= KU15-07;V_6=KU15-89 (TU-22), V_7=KU15-102 (IU05-1),V_8=KU16-77 (KPU12-1730), V_9=KU17-64(DBG-11),V_{10}=KU17-80(AKU13-16)

Table 4: Photothermal units at different phenophases of blackgram varietiesduringpost-*kharif*season

Variety	Photothermal units(°Chour)				
	Sowing to emergence (S -E)	Emergence to flower initiation (E-FI)	Flower initiation to pod initiation (FI -PI)	Pod initiation to maturity (PI-M)	Sowing to maturity (S-M)
V_1	898.71	7921.84	2729.07	4217.27	15766.88
V_2	1114.22	7986.75	2642.79	4165.10	15908.86
V_3	970.54	8187.43	2768.84	4265.83	16192.65
V_4	1341.19	7894.99	2881.27	3941.33	16058.77
V_5	1265.53	7838.48	2839.98	3898.57	15842.57
V_6	1114.22	7706.33	2729.07	3911.01	15460.62
V_7	1042.38	7989.58	2906.86	3828.07	15766.89
V_8	1193.69	7964.28	2947.46	3792.09	15897.53
V_9	1114.22	7917.74	2711.80	4165.77	15909.53
V_{10}	1042.38	8196.61	2699.83	4069.79	16008.61
SEm (±)	**68.72**	**104.48**	**82.08**	**46.35**	**35.07**
LSD (0.05)	**205.75**	**NS**	**NS**	**138.78**	**104.99**

NS=Not significant, V_1= Pant U 19; V_2= Pant U 31; V_3= Pant U 35; V_4= KU14-16 (Uttara); V_5= KU15-07;V_6=KU15-89 (TU-22), V_7=KU15-102 (IU05-1),V_8=KU16-77 (KPU12-1730), V_9=KU17-64(DBG-11),V_{10}=KU17-80(AKU13-16)

in growth duration (Table 1). However, Mane *et al*. (2017) reported much more GDD (1852.8^{0}C) on black gram variety BDU-1 for its entire life cycle during *kharif* season at Parbhani, Maharastra, India.

Heliothermal units (HTU)

Like GDD, accumulated HTU varied significantly at all the phenophases excluding emergence to flower initiation (E-FI) and flower initiation to pod initiation (FI-PI) in the study (Table 3). Mean cultivar HTU from sowing to emergence, flower initiation, pod initiation and maturity stages were 473.08, 4427.24, 6036.65 and 8542.07^{0}C hour, respectively. Among 10 varieties, maximum HTU was accumulated by V_4 (627.98p C hour), V_{10} (4112.99^{0}C hour), V_8 (1732.63^{0}C hour) and V_1 (2654.37^{0}C hour) at sowing to emergence (S-E), emergence to flower initiation (E-FI), flower initiation to pod initiation (FI-PI) and pod initiation to maturity

Table 5: Yield, heat use efficiency and protein content of blackgramv arieties during post-*kharif* season

Variety	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)	Heat use efficiency (kg ha^{-1}°C day^{-1})	Protein (%)
V_1	1057.17	2975.74	26.15	0.79	21.17
V_2	815.44	2847.77	22.30	0.61	21.61
V_3	1097.22	3182.41	25.64	0.82	21.26
V_4	1044.82	3774.07	21.70	0.78	21.08
V_5	1022.96	3294.44	23.75	0.76	24.42
V_6	940.28	2938.15	24.24	0.70	22.75
V_7	896.53	3157.96	22.13	0.67	19.07
V_8	1144.81	2458.51	31.80	0.85	21.43
V_9	875.00	2327.03	27.41	0.65	22.23
V_{10}	1045.69	3370.37	23.61	0.78	21.35
SEm (±)	**60.225**	**109.430**	**1.47**	**0.045**	**0.27**
LSD (0.05)	**180.325**	**327.653**	**4.41**	**0.135**	**0.80**

NS=Not significant, V_1= Pant U 19; V_2= Pant U 31; V_3= Pant U 35; V_4= KU14-16 (Uttara); V_5= KU15-07; V_6=KU15-89 (TU-22), V_7=KU15-102 (IU05-1), V_8=KU16-77 (KPU12-1730), V_9=KU17-64(DBG-11), V_{10}=KU17-80(AKU13-16)

stage (PI-M), respectively. KU 14-16 (V_4) required maximum summed HTU (8710.03°C hour) to complete the life cycle, being closely followed by V_3 (8670.03°C hour), while KU 15-89 (V_6) had lowest summed HTU (8277.72°C hour) from sowing to maturity. A careful study of the data presented in Table 3 indicated that Pant U 31 (V_2), KU 16-77 (V_8) and KU 17-64 (V_9) accumulated similar summed HTU (8533.63 - 8583.72°C hour), while Pant U 19 (V_1), KU 15-07 (V_5) and KU 15-102 (V_7) had near-similar summed HTU (8481.80 - 8481.94°C hour) for entire life cycle.

PTU- Mean cultivar summed photothermal units at different phenophases were recorded as: 1109.71°C hour (sowing to emergence), 7960.40°C hour (emergence to flower initiation), 2785.70°C hour (flower initiation to pod initiation), 4025.48°C hour (pod initiation to maturity) and 15881.29°C hour (sowing to maturity) (Table 4). Like GDD and HTU, ten varieties differed significantly due to photothermal requirements during early (sowing to emergence) as well as late stages (pod initiation to maturity) of blackgram in this study.

Among ten blackgram varieties, KU 15-89 (V_6) accumulated lowest photothermal units (15460.62°C hour) for entire life-cycle, while Pant U 35 (V_3) had maximum PTU (16192.65°C hour) from sowing to maturity.

The heat use efficiency was found to vary significantly among 10 varieties of blackgram tested in the study. The variation in HUE was noted between 0.607 kg ha^{-1}°C day^{-1} (Pant U 31) and 0.852 kg ha^{-1}°C day^{-1} (KU 16-77) during post-*kharif* season (Table 5). Grain yield, an end product of interaction among yield components, differed significantly due to varieties in the study (Table 5)

Based on yield performances, ten varieties could be arranged as: KU 16-77 (1144.81 kg ha^{-1}) > Pant U 35 (1097.22 kg ha^{-1}) > Pant U 19 (1057.17 kg ha^{-1}) > KU 17-80 (1045.69 kg ha^{-1}) >> KU 14-16 (1044.82 kg ha^{-1}) > KU 15-07 (1022.96 kg ha^{-1}) > KU 15-89 (940.28 kg ha^{-1}) > KU 15-102 (896.53 kg ha^{-1}) >KU 17-64 (875.00 kg ha^{-1}) > Pant U 31 (815.44 kg ha^{-1}).Therefore, KU 16-77 (V_8) yielded highest (1144.81 kg ha^{-1}), which was 329.30 kg ha^{-1} greater over the lowest yielding one (V_2).

The findings on yield components indicated that though KU 16-77 (V_8), Pant U-35 (V_3) and Pant U-19 (V_1) produced less number of pods plant^{-1} and seeds pod^{-1}, but they had much higher test weight (>50g) due to larger seed size and thus they gave higher seed yield (1144.81, 1097.22 and 1057.17 kg ha^{-1}) compared to other blackgram varieties tested in the study. Near similar seed yield of Pant U 35 *i.e*.11.07 q ha^{-1} was reported by Panotra *et al*. (2016) during *kharif*, 2008 at Uttar Pradesh; while it gave lower yield (962 kg ha^{-1})at Rajasthan during *kharif*, 2015 (Choudhary *et al*., 2017).

Stover yield, the combined effect of plant height, branching habit and leaf growth, varied significantly among 10 blackgram varieties tested in the experiment (Table5). KU14-16 (V_4) produced the highest stover yield (3774.07kg ha^{-1}), while KU 17-64 (V_9) recorded the lowest stover yield (2327.03 kg ha^{-1}). A careful study revealed that Pant U 19 (V_1) Pant U 31 (V_3) and KU 15-89 (V_6) produced more or less similar stalk yield (2847.77- 2975.74 kg ha^{-1}).

The variations in grain and straw yields due to cultivars led to differences in harvest index among them (Table 5). Mean cultivar harvest index was as 24.87% with a range between 21.70% (KU14-16) and 31.80% (KU16-77) in the experiment.

HUE : The heat use efficiency was found to vary significantly among 10 varieties of blackgram tested in the study. The variation in HUE was noted between 0.607 kg ha^{-1}°C day^{-1} (Pant U 31) and 0.852 kg ha^{-1}°C day^{-1} (KU 16-77) during post- *kharif* season at Jaguli, Nadia,West Bengal (Table 5).

Protein content

Significant variation in protein content was observed among ten blackgram varieties tested in the study during late-*kharif* of 2018 (Table 5). KU 15-07 (V_5) recorded the highest protein content (24.42%), which was distantly followed by KU 15-89 (22.75%) and KU 17-64 (22.23%) KU 15-102 (V_7) had lowest protein content (19.07%) in the study.Other six varieties (viz. V_1,V_2, V_3, V_4, $V_8$and V_{10}) had near similar protein content ranging between 21.08 and 21.61%.

From the experimental study it was observed that the mean cultivar days from sowing to emergence, flower initiation, pod initiation and maturity of blackgram were 4.93, 42.17, 57.57 and 83.40 days, respectively. Among 10 blackgram varieties studied in the experiment, number of days to maturity varied between 81.33 days (V_6) and 84.67 days (V_3 and V_4). The average summed GDD, HTU and PTU for entire life cycle were recorded as 1339.59^{0}C day, 8542.07^{0}C hour and 15881.29^{0}C hour, respectively. The variation in HUE among ten varieties was noted between 0.607 kg ha^{-1} ^{0}C day^{-1} (Pant U 31) and 0.852 kg ha^{-1}°C day^{-1} (KU 16- 77). In case of protein content in seeds, KU 15-07 (V_5) recorded highest value (24.42%) followed by KU 15-89 (22.75%) and KU 17-64 (22.23%), while KU 15- 102 had lowest protein content (19.07%). All the ten blackgram cultivars tested in the study had more or less same duration and had total GDD of 1300-1400°C days.

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REFERENCES

Ali, M. and Kumar, S. 2008. Pulse crops of India In: *The Hindu Survey of Indian Agriculture. Ernaculam Malyalam Manorma*, pp. 43-46.

Choudhary, G.L., Sharma, S.K., Choudhary, S., Singh, K.P., Kaushik, M.K. and Bazaya, B.R. 2017. Effect of panchagavya on quality, nutrient content and nutrient uptake of organic blackgram [*Vignamungo* (L.)Hepper]. *J. Pharmacog. Phytochem.*,**6**(5):1572-1575.

Esfandiary, F., Aghaie, G. and Mehr, A.D. 2009. Wheat yield prediction through agro meteorological indices for Ardebil District. *Int. J.Biol. Life Sci.*,**1**:48-51.

FAO, 2004.The State of Food Insecurity in the World 2004, Rome.

ICARDA, 2016. Annual Report.Enhancing food and nutritional security and improved livelihood through intensification of rice fallow system with pulse crop in South Asia (Bangladesh, India and Nepal).International Centre for Agricultural Research in the Dry Areas, New Delhi, India.

Mane, R.B., Asewar, B.V., Chavan, K.K. and Kadam, Y.E. 2017.Study of agro meteorological indices on blackgram as affected by different dates of sowing and varieties. *J. Agric. Res. Tech*., **42**(3):126-131.

Nuttonson, M. Y. 1955. Wheat-climate relationships and the use of phenology in ascertaining the thermal and photo-thermal requirements of wheat based on data of North America and of some thermally analogous areas of North America in the Soviet Union and in Finland. *Wheat-climate relationships and the use of phenology in ascertaining the thermal and photo-thermal requirements of wheat based on data of North America and of some thermally analogous areas of North America in the Soviet Union and in Finland.*

Panotra, N., Kumar, A. and Singh, O.P. 2016. Effect of varieties and dates of sowing on growth parameters, yield attributes and yield of blackgram (*Vigna mungo* L.). *Int. J. Sci. Environ. Tech.*,***5***(6): 3821-3826.

Patidar, R. 2015. Performance of blackgram (*Vignamungo* L.) varieties under rainfed farming situation. M.Sc (Ag) Thesis, JNKVV, India.

Singh, G., Kaur, H., Aggarwal, N. and Ram, H. 2013. Symbiotic efficiency, thermal requirement and yield of blackgram (*Vigna mungo* L.) genotypes as influenced by sowing time. *Ind. J, Agric. Sci.,***83**(9):953-958.

Singh, G., Virk, H.K., Singh, S., Singh, K., Singh, S. and Gill, K.K. 2017. Thermal requirements, growth and yield of pigeonpea [*Cajanuscajan* (L.) Mill sp.]genotypes under different agroclimatic zones of Punjab. *J.Appl. Natural Sci.,***9**(4): 2377- 2384.