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Evaluation of Garden Pea (*Pisum sativum* var. *hortense* L.) Genotypes Under Irrigated and Rainfed Condition Under Foothills of Terai Agro-ecological Region of West Bengal

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Abstract

The experiment was carried out to study the performance of garden pea genotypes for growth, yield and quality during *rabi* season (November to april) of 2017–18 and 2018–19 with the help of split plot design through three number of replications. The results of the study revealed that, early flowering, flowering at early node and days to first harvest was earlier by 2.32, 2.90 and 0.89 days, respectively in rainfed conditions. Yield parameters like individual plant yield, number of pods plant^{-1}, individual pod weight and total fresh yield were significantly reduced by water stress condition. Number of nodules plant^{-1} (7.93) and nodule dry weight (97.01 g) decreased in rainfed conditions, whereas root length (22.33 cm) was higher in rainfed condition. Considering yield, benefit cost ratio and moisture stress tolerance of garden pea genotypes, TSS content of fresh seeds was higher in rainfed conditions. Quality parameters such as protein content and shelling percentage were higher in irrigated conditions. Ascorbic acid content remained unchanged under both growing conditions. The varieties such as Arka Apoorva, Arka Priya, Goldie and GS-10 may be selected for cultivation under both irrigated and rainfed conditions. On the basis of *per se* performance and drought tolerant indices Arka Apoorva, Arka Priya and Jindal-10 may be selected as suitable for growing under moisture stress condition in terai agro-ecological condition of West Bengal.

Keywords: Garden pea, genotypes, moisture stress, tolerance

1. Introduction

Garden pea (*Pisum sativum* var. *hortense* L.) is an important cool season legume vegetable crop (Rabbi et al., 2011). It is a nutritious vegetable and rich source of protein, carbohydrate, Vit-A, Vit-C, potassium, phosphorous, minerals, dietary fibers and antioxidant compounds (Urbano et al., 2003). Each 100 g edible portion of the green pea contains moisture 78 g, protein 6.3 g, carbohydrates 14.4 g, energy 84 Kcal, calcium 26 mg, phosphorus 116 mg, iron 1.9 mg and vitamin A 640 IU (Thamburaj, 2013). On the basis of seed pea cultivars are divided into two classes, i.e., smooth or wrinkle seeded types; on the basis of height cultivars are classified into three classes, i.e., bush, medium tall and tall types and according to maturity three classes are early, mid

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season and late cultivars (Datta and Das, 2018). Garden pea is consumed as fresh or cooked vegetable, it is also consumed as processed products like canned, dehydrated and frozen for consumption in off season. In India garden pea occupies about 2.5% of total vegetable production with 9.8 t ha^{-1} of average national productivity (Anonymous, 2018). India is the largest producer of garden pea next to China (Avramenko, 2017). Productivity of the crop in the northern parts of the West Bengal is (6 t ha^{-1}) as compared to the nation-al average (9.5 t ha^{-1}) (Anonymous, 2011). Indian agriculture is mostly dependent on rainfall, in recent years the annual rainfall has been drastically reduced. Hence, there is acute shortage of water for agriculture. Abiotic stresses like high light intensity, high temperature, water deficit and nutritional deficiency, reduces the agricultural production and quality of crop produce (Lawlor, 1979; Boyer, 1982; Xiong et al., 1999). Moisture stress, both as seasonal phenomenon and as a part of climate change, is currently the leading threat to world's food supply. This stress is more even severe than other abiotic stresses, making it threat to crop production. Salter (1962, 1963) reported that flowering and pod swelling are the critical stages of growth, adequate water is essential for high yield of green peas.

In the existing circumstance of climate revolutionize, we are witnessing an boost in the heterogeneity of rainfall with discontinuous periods of important rainfall and drought (Bernstein et al., 2007; Dai, 2013), causing plant yield and seed protein content instability, and causative as an instance to the decrease in the cultivated area of pea (Cernay et al., 2015). While stomatal closure reduces water defeat, it can also diminish plant photosynthesis and thus reduce biomass accretion (Chaves et al., 2003; Xu et al., 2010).

With the changing of human food habit the presence of garden pea in the market over all periods of a year is prefers by the customers. But, due to the changing climate day by day, the existing climactic condition differs and the shortage of water comes with a big constrain in crop production. The terai agro-ecological region of West Bengal basically a sub-humid region, but recent days the crop production was hampered due to less rainfall and shortage of water. Upon considering that point the present experiment conducted to know the difference crop performance by adapting rainfed and irrigated condition. Along with this another objective of the present study was to find out the suitable variety in different conditions.

2. Materials and Methods

The field experiment was conducted at the Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India, during *rabi* (November to April) season of 2017–18 and 2018–19. Geographically the farm is situated at 26°19´86" N latitude and 89° 23' 53"E longitude, at an elevation of 43 Anonymous m MSL which is a part of terai zone of West Bengal. The experiment was carried out in split plot design, irrigated and rainfed conditions as two main plots and 15 genotypes of garden pea as sub-plots. The different growing conditions, different genotypes and their interaction was randomized with three replication without making any buffer channel. Seeds before sowing were treated with *Rhizobium leguminosarum* @ 20 g kg^{-1} of seeds and sown at a spacing of 45×15 cm^2 (R×P) in plots of size 2.25 ×2.0 m^2. Recommended dose of fertilizers along with FYM and vermicompost were added during land preparation. Irrigation was provided in irrigated plots and no irrigation was given to rainfed plots. The observations on growth and yield parameters of garden pea such as, plant height, days to flowering and first harvest, number of pods $plant^{-1}$, individual pod weight, individual plant yield, plot yield, total fresh yield, root length number of nodules $plant^{-1}$ and nodule dry weight of plants were recorded. With respect to quality parameters, shelling percentage, protein content (%), TSS (Brix) and ascorbic acid content (mg 100 g^{-1}) of fresh seeds were estimated (Sadasivam and Manickam, 1996). The pooled data for different treatment is discussed here against different morphological and bio-chemical parameters. Along with the pooled data of interaction effect is also discussed because of the significant relationship between them.

Benefit cost ratio of garden pea cultivation under both growing conditions were calculated by determining the cost incurred for per hectare cultivation (C) and cost of price per unit production per hectare (R) by the formula

Net return=Gross returns (R)–Cost of cultivation Returns (C) (Rs ha^{-1})

Benefit cost ratio=Net returns/Total cost of cultivation

2.1. Drought tolerant indices

Drought intensity index= $(1–X_{DS})/ X_{NS}$ (Fischer and Maure. 1978)

Drought susceptibility index= $\{(1-Y_{DS}/Y_{NS})/(1- X_{DS}/X_{NS})\}$ (Fischer and Maure, 1978).

Drought tolerance index= $(Y_{DS}\ Y_{NS})/ X^2_{NS}$ (Fernandez, 1992).

Mean productivity= $(Y_{DS}+Y_{NS})/2$ (Rosielle and Hamblin, 1981).

Geometric mean productivity= $\sqrt{(Y_{DS}\ Y_{NS})}$ (Fernandez, 1992).

Yield reduction rate (%)= $\{(Y_{NS}- Y_{DS})/Y_{NS}\}\times100$ (Rosielle and Hamblin, 1981).

Yield stability index= Y_{DS} / Y_{NS} (Bouslama and Schapaugh, 1984).

Stress tolerance index= $(Y_{DS}+Y_{NS})/Y^2_{NS}$ (Fernandez, 1992).

Were, Y_{NS}: Mean yield of genotype evaluated under irrigated condition.

Y_{DS}: Mean yield of genotype evaluated under rainfed condition.

X_{NS}: Mean seed yield over all genotype evaluated under irrigated condition.

X_{DS}: Mean seed yield over all genotype evaluated under rainfed condition. (Fischer and Maure, 1978).

3. Results and Discussion

3.1. Growth and flowering parameters

The experimental results revealed that, irrigation had significantly influenced the plant height and was higher in irrigated condition (80.94 cm) and low in rainfed condition, this may be due to irrigation had influenced absorption of nutrients and increases cell division and hence more vegetative growth. Among the genotypes higher plant height was noted in Arka Apoorva (108.90 cm) and low in KSP-10 (61.98 cm). Flowering early node was recorded in rainfed condition (9.26 cm) and delayed node in irrigated condition (10.15). Early flowering and early first harvesting was noticed in rainfed condition (46.89 DAS and 71.90 DAS respectively) and was delayed in irrigated condition (49.93 DAS and 74.80 DAS respectively) as increased vegetative growth delayed flowering under irrigated conditions. Agarwal et al. (2006) and Khan et al. (2013) also reported that there was a significant variation in days to flowering among the cultivars. Considering the genotypes irrespective of growing conditions, early flowering and early first harvesting was recorded in Arkel (46.89 DAS and 62.18 DAS respectively) and delayed in Arka Apoorva (57.89 DAS and 79.13 DAS respectively). The findings were in harmony with Datta and Das (2018). Variation within genotypes for plant height, days to flowering and first harvest may be due to environmental and genetic characteristics of genotypes (Kumar et al., 2008). Moisture stress increased the root length and found to be maximum in rainfed condition (22.33 cm) and minimum in irrigated condition (19.28 cm), with respect to genotypes it was maximum in GS-10 (23.30 cm) and minimum in Arka Priya (18.66 cm). Number of nodules per plant and nodule dry weight were higher in irrigated condition (8.54 and 104.47 mg respectively), among the genotype's maximum nodule number and nodule dry weight was found in KSP-10 (11.44 and 140.01 mg respectively) and were lower in Arkel (5.79 and 70.90 mg respectively) (Table 1).

3.2. Yield parameters

Yield attributing parameters and yield were significantly affected by the moisture stress. Highest number of pods were recorded in irrigated condition (13.57) and reduced in rainfed condition (11.15). In case of different genotypes more pods were harvested in GS-10 (16) and lower pods in Pan-4009 (9.97). Considering the individual pod weight,

Table 1: Effect of different growing conditions on growth and yield of garden pea genotypes

Treatments	Plant height (c)	Node at first flower	Days to flowering	Days to first harvest	Root length (cm)	No. of nodules plant^{-1}	Nodule dry weight (g)	No. of pods plant^{-1}	Individual pod weight	Individual plant yield (g)
Growing conditions										
Rainfed	74.81	9.26	51.87	71.90	22.33	7.93	97.01	11.15	6.07	52.48
Irrigated	80.93	10.15	54.19	74.80	19.28	8.54	104.57	13.57	6.89	70.95
SEM±	0.18	0.09	0.02	0.22	0.07	0.03	0.41	0.03	0.02	0.83
CD (*p*=0.05)	0.52	0.56	1.03	1.41	0.20	0.10	1.16	0.17	0.11	5.44
Genotypes										
Arkel	67.70	8.87	46.89	62.18	18.77	5.79	70.90	10.87	6.28	50.25
Arka Priya	102.73	9.94	56.48	77.51	18.66	6.73	82.33	15.05	6.09	71.85
Arka Apoorva	108.90	8.68	57.89	79.13	20.71	6.73	82.41	10.60	10.23	73.10
GMS-10	62.06	8.87	52.96	74.53	23.06	8.49	103.94	10.20	6.64	51.72
Pan-4009	70.07	9.95	53.12	74.54	20.24	7.64	93.54	9.97	6.76	51.05
MK-10	70.95	8.73	54.90	77.50	19.62	8.09	99.05	10.20	7.06	58.56
Jindal-10	90.02	9.33	52.50	72.24	22.06	9.30	113.81	10.40	6.50	51.94
PS-10	67.86	10.11	51.98	71.34	19.66	8.96	109.65	13.13	6.65	70.14
BL-10	68.30	9.83	51.11	69.84	20.54	7.81	95.65	12.55	6.30	63.66
MSC-10	69.00	9.75	51.31	70.24	19.34	9.03	110.52	12.88	5.96	62.47
GS-10	78.40	10.00	54.39	74.61	23.30	10.20	124.79	16.00	5.59	73.08
KSP-10	61.98	9.72	54.43	75.76	22.96	11.44	140.01	11.92	6.18	58.40
NP-20	74.75	10.25	54.95	75.33	21.42	7.60	93.00	13.30	5.14	54.14
Super-70	89.17	10.53	52.61	74.23	20.51	7.88	96.44	12.73	6.06	61.84
Goldie	86.18	11.00	49.93	71.32	21.20	7.82	95.76	15.57	5.80	73.49
SEm±	0.51	0.11	0.48	0.84	0.20	0.09	1.12	0.15	0.06	0.98
CD (*p*=0.05)	1.44	0.32	1.37	2.39	0.56	0.27	3.19	0.43	6.28	50.25

irrigation condition recorded higher individual weight (6.89 g) and lower in rainfed condition (6.07 g). Looking into genotypes irrespective of growing condition, Arka Apoorva recorded highest pod weight (10.23 g) and was lowest in NP-20 (5.14 g), Khichi et al. (2016) reported similar yield, highest pod weight in PB-89 (6.12 g) and lowest in Arka Karthik (3.27 g). With respect to individual plant yield, irrigation had a significant impact on plant yield and recorded maximum yield under irrigated condition (70.95 g) and reduced in rainfed condition (52.48 g). It was observed that genotypes regardless of growing condition significantly varied. Arka Apoorva (73.10 g) had noted higher yields and lower in Arkel (50.25 g). The results were analogous to results obtained by Khichi et al. (2016). Considering the plot yield, as parallel to yield plant^{-1}, plot yield was more in irrigated condition (4.81 kg) as along with number of pods plant^{-1} and individual pod weight were also higher in irrigated condition than the rainfed condition and hence rainfed condition recorded lower plot yield (3.71 kg). Arka Priya obtained higher plot yield (5.20 kg) and lowest in Arkel (3.36 kg). with respect to fresh pod yield, as higher pod number, individual pod weight, individual plant yield and plot yield were higher in irrigated conditions, fresh yield was higher in irrigated condition (9.09 t ha^{-1}) and reduced in rainfed condition (7.01 t ha^{-1}), on an average of 20% yield reduction was observed from irrigated to rainfed condition. Positive association of yield with plant height and pod number per plant was observed by Hatam and Amanullah (2001). Maximum yield was recorded in Arka Apoorva (9.81 t ha^{-1}) and Arka Priya (9.81 t ha^{-1}). Similar type of results has also been reported by Lal et al. (2011) and Singh et al. (2012). Lowest yield were noticed in Arkel (6.35 t ha^{-1}). Yield was found to be a complex character obtained by the interaction of many heritable characters with soil, climate, and agronomic conditions (Makasheva, 1983). Maximum yield involves maximum vegetative growth during crop establishment (Muehlbauer and McPhee, 1997), in our present study, vegetative growth of pea plants was found to be lower in rainfed condition as early flowering, first flower at early node and early harvest was noticed in rainfed condition that would have led to lower yields in rainfed condition (Table 2).

Table 2: Effect of different growing conditions on growth and yield of garden pea genotypes

Treatments	Plot yield (kg plot^{-1})	Green pod yield (t ha^{-1})	Protein content (%)	Shelling percentage	Vit-C (mg 100 g^{-1} fresh)	TSS (Brix)	Chlorophyll a:b
Growing conditions							
Rainfed	3.71	7.01	4.08	41.34	27.80	10.10	2.27
Irrigated	4.81	9.09	4.67	46.77	27.79	9.53	2.33
SEM±	0.02	0.04	0.01	0.15	0.09	0.12	0.01
CD (*p*=0.05)	0.14	0.28	0.03	0.98	NS	0.34	0.04
Genotypes							
Arkel	3.36	6.35	4.10	46.04	24.03	7.21	2.27
Arka Priya	5.20	9.81	4.51	46.84	20.55	6.81	2.44
Arka Apoorva	5.19	9.81	4.62	44.48	26.09	10.91	2.30
GMS-10	3.69	6.97	4.25	46.78	30.22	10.03	2.29
Pan-4009	3.57	6.73	3.90	42.62	26.54	12.78	2.30
MK-10	4.14	7.81	4.19	44.50	26.09	8.80	2.37
Jindal-10	3.51	6.63	4.39	46.23	30.24	8.88	2.27
PS-10	5.01	9.47	4.47	43.51	23.17	11.33	2.15
BL-10	4.23	7.98	5.07	44.01	31.89	10.15	2.32
MSC-10	3.99	7.53	3.94	42.85	31.20	8.65	2.31
GS-10	4.96	9.37	4.15	43.15	26.40	11.06	2.33
KSP-10	4.01	7.57	4.40	42.91	28.66	10.85	2.38
NP-20	3.82	7.22	4.85	39.70	32.22	10.38	2.26
Super-70	4.07	7.70	4.24	43.17	28.69	9.84	2.30
Goldie	5.19	9.80	4.57	46.04	30.97	9.52	2.26
SEm±	0.06	0.11	0.03	0.37	0.24	0.33	0.03
CD (*p*=0.05)	0.17	0.32	0.09	1.06	0.68	0.93	0.10

3.3. Quality parameters

Moisture content significantly influenced quality parameters such as protein content, shelling percentage, total soluble solids and chlorophyll *a:b* ratio. Higher protein content on fresh weight basis was observed in irrigated condition (4.67%), it was lower in rainfed condition (4.08%), As reported by Foroud et al. (1993) in case of soybean protein content was reduced by drought stress condition and it was higher in irrigated condition. Variation in protein percentage of seeds among the different genotypes of garden pea was also reported by Phom et al. (2014). BL-10 (5.07%) recorded higher protein content and it was found to be lower in span hyphen 4009 (3.90%). Shelling percentage was phoned to be higher in irrigated condition (46.42%) as the water content increase the fresh weight of the seeds. It was found to be lower in rain fed conditions (41.32%) as the water content of the seeds and pods is lower reduces the fresh weight irrespective of the genotype. Arka Priya (47.36%) recorded higher shelling percentage and is found to be lower in case of NP-20 (39.81%) regardless of growing conditions. Variation within the genotypes with respect to selling percentage is due to the genetic characteristic of the genotype which was given by Chadha et al. (2013). Vitamin C content was not influenced by the water stress condition and it was found to be unchanged under both the conditions Robinson and Bunces (2000) found that ascorbic acid content of soybean remained unchanged under drought conditions. Among genotypes Vitamin-C content showed significant difference, BL-10 (31.89 mg 100 g^{-1}) recorded higher and lower in Arka Priya (20.55 mg 100 g^{-1}) on fresh weight basis. TSS content was higher in rainfed condition (10.10° brix) than irrigated condition (9.53° brix). Significant differences among genotypes for TSS content was noticed and found to be maximum in Pan-4009 (13.07° brix) and minimum in Arka Priya (6.43° brix). Ratio of chlorophyll *a:b* was reduced by drought stress condition (2.27) and it was higher in irrigated condition (2.33). Zain et al. (2014) reported that total chlorophyll, chlorophyll *a* and chlorophyll *b* was reduced by drought stress conditions and intensity of reduction is influenced directly by duration of drought stress condition. However, Mafakheri et al. (2010) found that the chlorophyll *a*/*b* ratio was not affected by drought stress as chlorophyll *b* is less sensitive to drought than chlorophyll *a.* With respect to genotypes regardless of growing environments there was significant difference, ratio value was higher in Arka Priya (2.44) and was lower in PS-10 (2.15).

3.4. Drought tolerance indices

Drought susceptibility index helps to identify the drought susceptible genotypes. Jindal-10 (0.95) genotype was highly susceptible to water stress and the genotype Pan-4009 was found to be tolerant to drought with less drought susceptibility index (DSI) (0.56). Darkwa et al. (2016) observed the similar results common bean and the data value ranged from -0.9 to 2.1. Based on the results on drought susceptibility index Pan-4009, Arkel and GS-10 can be selected as drought tolerant genotypes. Pan-4009 genotype (4.16) had highest drought tolerant index value and the lowest values were found in GMS-10 (2.69). Based on the pooled data it was evident that Pan-4009, Arka Apoorva and Arkel were selected as drought tolerant genotypes depending on different drought tolarent index. Hendawy et al. (2017) suggested that drought tolerance index can be used as selection criteria for drought tolerance, but, it did not identify the high yielding genotypes under both growing conditions. Arka Priya (9.81), Arka Apoorva (9.80), Goldie (9.80) and PS-10 (9.47) were selected as high yielding genotypes based on their mean productivity. Mean productivity is a selection criterion for drought tolerance as suggested by Cabello et al. (2013) and Zare. (2012). Arka Apoorva (9.77), Arka Priya (9.76) and Goldie (9.65) genotypes were found to be high yielding and recorded higher values for geometric mean productivity. The genotypes Arka Apoorva (9.74) and Arka Priya (9.71) obtained higher values for harmonic mean productivity. Mau et al. (2019) suggested harmonic mean productivity as better criteria for selection as high yielding genotypes under both conditions and similar concept was also given by Hendawy et al. (2017) and Gholinezhad et al. (2014) (Table 3).

Table 3: Drought tolerant indices of garden pea genotypes

Genotypes	Drought susceptibility index	Drought tolerance index	Mean productivity	Geometric mean productivity
Arkel	0.56	3.91	6.35	6.34
Arka Priya	0.71	3.37	9.81	9.76
Arka Apoorva	0.79	4.08	9.80	9.77
GMS-10	0.84	2.69	6.97	6.81
Pan-4009	0.55	4.16	6.73	6.71
MK-10	0.83	3.75	7.81	7.76
Jindal-10	0.95	3.90	6.63	6.60
PS_10	0.72	3.52	9.47	9.38
BL-10	0.66	3.65	7.98	7.94
MSC_10	0.81	3.14	7.53	7.36
GS-10	0.57	3.30	9.37	9.30
KSP-10	0.75	3.33	7.57	7.46
NP-20	0.60	3.78	7.22	7.15
Super-70	0.72	3.56	7.69	7.62
Goldie	0.77	3.20	9.80	9.65

Stress tolerance index is a ideal selection criteria for drought tolerance (Hendawy et al., 2017, Darkwa et al., 2016). Higher the value of stress tolerance higher is the tolerance level of genotype. Arka Apoorva (1.16), Arka Priya (1.15), Goldie (1.13) and PS-10 (1.06) recorded higher values for stress tolerance index and can be selected as drought tolerant and high yielding genotypes for their higher stress tolerance index. Yield reduction rate is calculated based on performance of genotypes under both conditions, an average yield reduction of 22.51% was observed from the pooled data. Lower yield reduction from irrigated to rainfed condition was observed in Arkel (9.81%) followed by Pan-4009 (13.5%) and Arka Apoorva (15.30%) and these genotypes were selected as drought tolerant. But yield reduction rate failed to distinguish the high and low yielding genotypes (Hendawy et al. (2017). Yield stability index was calculated from the yield data recorded from both conditions. Values closer to 1 can be selected as drought tolerant genotypes (Hendawy et al., 2017). The genotypes Arkel (0.90), Pan-4009 (0.86) Arka Apoorva (0.85), Jindal-10 (0.84) and Arka Priya (0.81) recorded higher values closer to 1 and were selected as drought tolerant genotypes (Table 4).

Table 4: Drought tolerant indices of garden pea genotypes

Genotypes	Stress tolerance index	Harmonic mean productivity	Yield reduction rate (%)	Yield stability index
Arkel	0.49	6.34	9.81	0.90
Arka Priya	1.15	9.71	18.54	0.81
Arka Apoorva	1.16	9.74	15.30	0.85
GMS-10	0.56	6.66	34.81	0.65
Pan-4009	0.55	6.70	13.56	0.86
MK-10	0.73	7.70	21.18	0.79
Jindal-10	0.53	6.58	15.99	0.84
PS_10	1.06	9.28	24.37	0.76
BL-10	0.76	7.89	19.64	0.80
MSC_10	0.66	7.19	34.83	0.65
GS-10	1.05	9.22	22.38	0.78
KSP-10	0.67	7.35	29.10	0.71
NP-20	0.62	7.08	24.42	0.76
Super-70	0.70	7.54	24.66	0.75
Goldie	0.77	3.20	29.54	0.70

4. Conclusion

On the basis of *per se* performance and drought tolerant indices genotypes Arka Priya, Arka Apoorva, Goldie and PS-10 can be selected as drought tolerant and high yielding genotypes for their higher stress tolerance index. The selected genotypes are recommended to be used as parents in a breeding program for improvement of drought tolerance and pod yield.

5. Reference

Agarwal, A., Gupta, S., Ahmed, Z., 2006. Performance of garden pea (*Pisum sativum*) cultivars in high altitude cold desert of Ladakh. Indian journal of Agricultural Sciences 76 , 713–715.

Anonymous, 2018. National horticulture database. National Horticulture Board, Govt. of India, Gurgaon, India.www.nhb.gov.in. 20th March, 2018.

Anonymous., 2011. Indian institute of vegetable research database. Indian Institute of Vegetable Research, Govt. of India., Varanasi, India.www.iivr.org.in.

Avramenko, S., 2017. Which country produces the most green peas in the World? Other Non-Perennial Crops, November 07, 2017, (https://www.indexbox.io/blog/which-country-produces-the-most-green-peas-in-the-world/)

Bernstein, L., Bosch, P., Canziani, O., Chen, Z., Christ, R., Davidson, O., 2007). Climate change 2007: Synthesis Report: An Assessment of the Intergovernmental Panel on Climate Change. Geneva: IPCC.

Bouslama, M., Schapaugh, W.T., 1984. Stress tolerance in soybeans. I. evaluation of three screening techniques for heat and drought tolerance. Crop Science 24, 933–937.

Boyer, J.S., 1982. Plant productivity and environment. Science 218, 443–448.

Cabello, R., Monneveux, P., Mendiburu, F.D., Bonierbale, M., 2013. Comparison of yield-based drought tolerance indices in improved varieties, genetic stocks and landraces of potato (*Solanum tuberosum* L.). Euphytica 193,147–156.

Cernay, C., Ben-Ari, T., Pelzer, E., Meynard, J.M., Makowski, D., 2015. Estimating variability in grain legume yields across Europe and the Americas. Scientific Reports 5, 11171.

Chadha, S., Rameshwar, Saini, J.P., Sharma, S., 2013. Performance of different varieties of pea (*Pisum sativum* L.) under organic farming conditions in mid Himalayas. International Journal of Agriculture and Food Science Technology 4(7), 733–738.

Chaves, M.M., Maroco, J.P., Pereira, J.S., 2003. Understanding plant responses to drought-from genes to the whole plant. Functional Plant Biology 30, 239–264.

Dai, A., 2013. Increasing drought under global warming in observations and models. Nature Climate Change 3, 52–58.

Darkwa, K., Ambachew, D., Mohammed, H., Asfaw, A., Blair, M.W., 2016. Evaluation of common bean (*Phaseolus vulgaris* L.) genotypes for drought stress adaptation in Ethiopia. The Crop Journal 4, 367–376.

Datta, S., Das, K., 2018. Varietal performance of garden pea (*Pisum sativum* var. *hortense*) under terai zone of West Bengal. Journal of Applied and Natural Science 10(3), 1032–1036.

Fernandez, G.C., 1992. Effective selection criteria for assessing plant stress tolerance. In proceeding of the international symposium on adaptation of vegetables and other food crops in temperature and water stress, Aug. 13-16, Shanhua, Taiwan, 257–270.

Fischer, R.A., Maure, R., 1978. Drought resistance in spring wheat cultivars. I Grain yield responses. Australian Journal of Agricultural Research 29, 897–912.

Foroud, N., Miindel, H.H., Saindon, G., Entz, T., 1993. Effect of level and timing of moisture stress on soybean yield, protein, and oil responses. Field Crops Research 31, 195–209.

Gholinezhad, E., Darvishzadeh, R., Bernousi, I., 2014. Evaluation of drought tolerance indices for selection of confectionery sunflower (*Helianthus anuus* L.) landraces under various environmental conditions. Notulae Botanicae Horti Agrobotanici 42(1), 187–201.

Hatam, M., Amanullah, 2001. Grain yield potential of garden peas (*Pisum sativum* L.) germplasm. Journal of Biological Sciences 1(4), 242–244.

Hendawy, S.E.E., Hassan, W.M., Suhaibani, N.A.A., Schmidhalter, U., 2017. Spectral assessment of drought tolerance indices and grain yield in advanced spring wheat lines grown under full and limited water irrigation. Agricultural Water Management 182, 1–12.

Khan, T.N., Ramzan, A., Jillani, G., Mehmood, T., 2013. Morphological performance of peas (*Pisum sativum* L.) genotypes under rainfed conditions of potowar region. Journal of Agricultural Research 51, 51–60.

Khichi, P., Chandan, P.M., Chauhan, J., Srinivas, J., Bhagat, M., 2016. Varietal evaluation of garden pea under semi-arid conditions of Vidharba region. International Journal of Farm Sciences 6(1), 20–24.

Kumar, A.V.R., Sharma, R.R., Deshmukh, P.S., 2008. Patterns of pod and seed growth during fruit development in garden pea genotypes. Indian Journal of Horticulture 65, 293–296.

Lal, G.M., Meena, M.L., Kunj, C.M., 2011. Assessment of genetic variability and interrelation between yield and its contributing components in field pea (*Pisum sativum* L.). Environmental Economics 29(3A), 1235–1239.

Lawlor, D.W., 1979. Effects of water and heat stress on carbon metabolism of plants with C3 and C4 photosynthesis. In: Mussel, H., Staples, R.C. (Eds), Stress Physiology in Crops Plants. New York, John Wiley, 304–326.

Mafakheri, A., Siosemardeh, A., Bahramnejad, B., Struik, P.C., Sohrabi, Y., 2010. Effect of drought stress on yield, proline and chlorophyll contents in three chickpea cultivars. Australian Journal of Crop Science 4(8), 580–585.

Makasheva, R.K., 1983. The pea. Oxonian Press Private Limited, New Delhi, India, 78–107.

Mau, Y.S., Ndiwa, A.S.S., Oematan, S.S., Markus, J.E.R., 2019. Drought tolerance indices for selection of drought tolerant, high yielding upland rice genotypes. Australian Journal of Crop Science 13(01), 170–178.

Muehlbauer, E.J., McPhee, K.E., 1997. Peas. In: Wein, H.C. (Ed.), The physiology of vegetable crops. CAB International, Wallingford, UK 429–459.

Phom, A.C., Kanaujia, S.P., Chaturvedi, H.P., 2014. Performance of various genotypes of pea under foothill condition of Nagaland. Annals of Plant and Soil Research 16, 285–288.

Rabbi, A.K.M.Z., Paul, A.K., Sarker, J.R., 2011. Effect of nitrogen and molybdenum on the growth and yield of garden pea (*Pisum sativum* L.). International Journal of Bio-resource and Stress Management 2(2), 230–235.

Robinson, J.M., Bunce, J.A., 2000. Influence of drought-induced water stress on soybean and spinach leaf ascorbate-dehydroascorbate level and redox status. International Journal of Plant Science 161(2), 271–279.

Rosielle, A.A., Hamblin, J., 1981. Theoretical aspects of selection for yield in stress and non-stress environments. Crop Science 21, 943–946.

Sadasivam, S., Manickam, A., 1996. Peroxidase methods in biochemistry, New Age International (P) Limited, New Delhi, 108–110.

Salter, P.J., 1962. Some responses of peas to irrigation at different growth stages. Journal of Horticultural Science 37, 141–149.

Salter, P.J., 1963. The effect of wet or dry soil conditions at different growth stages on the components of yield of a pea crop. Journal of Horticultural Science 38, 321–334.

Singh, M., Malik, S., Singh, M.K., Kumar, K.V.S., Dev, P., Kumar, V., 2012. Studies of variability, heritability and genetic advance in field pea (*Pisum sativum* L.). Progressive. Agriculture 12(1), 219–222.

Thamburaj, S., Singh, N., 2013. Vegetables, tubercrops and spices. Directorate of knowledge man-agement in agriculture., Indian Agricultural Research Institute, New Delhi, India 4–198.

Urbano, G., Aranda, P., Gomez-Villalva, E., 2003. Nutritional evaluation of pea (*Pisum sativum* L.) protein diets after mild hydrothermal treatment and with and without added phytase. Journal of Agricultural and Food Chemistry 51, 2415–2420.

Xiong, L., Ishitani, M., Zhu, J.K., 1999. Interaction of osmotic stress, temperature, and abscisic acid in the regulation of gene expression in Arabidopsis. Plant Physiology 119, 205–212.

Xu, Z., Zhou, G., Shimizu, H., 2010. Plant responses to drought and rewatering. Plant Signalling Behaviour 5, 649–654.

Zain, N.A.M., Ismail, M.R., Puteh, A., Mahmood, M., Islam, M.R., 2014. Impact of cyclic water stress on growth, physiological responses and yield of rice (*Oryza sativa* L.) grown in tropical environment. Ciencia Rural, Santa Maria 44(12), 2136–2141.

Zare, M., 2012. Evaluation of drought tolerance indices for the selection of Iranian barley (*Hordeum vulgare*) cultivars. African Journal of Biotechnology 11(93), 15975–15981.