Germination, Seedlings vigour and Salt tolerance index of mungbean genotypes under enhanced levels of salt stress

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Abstract **- Ten genetically diverse genotypes of mungbean (*Vigna radiata* L. Wilczek) were assessed for their salinity tolerance at 4 ESP (10, 20, 30, 40) levels in pot experiment for germination percentage (GP), shoot and root length and their fresh and dry weight, seedlings vigour and salt tolerance capacity during summer, 2020 at Soil Salinity Farm, Dileep Nagar, Kanpur. Genotype EC 88 followed by I 10 exhibited least reduction (13.47% and 14.78%, respectively) in germination percentage at highest level of salt concentration, maximum reduction (41.51%) in GP was observed in Pusa Vishal, KM 2241 followed by EC 88 showed least reduction in shoot and root length as compared to other genotypes at 40 ESP. KM 2241 again proved to be a good genotype with comparatively less reduction in shoot and root dry weight at high salt stress condition. Seedling vigour index was highest of KM 2241 followed by I 51 at high salt concentration (40 ESP). These genotypes showed comparatively less reduction in seedling vigour over Control. Salt tolerance index (STI) value was highest for KM 2241 followed by IPM 99-125 and I 51 at 40 ESP. KM 2241 appeared be a good genotype possessing gene (s) for tolerance to high concentration of salt which can be used as donor parent in hybridization programme of mungbean aimed at improving seed germination and seedling vigour.**

Index Terms - S**alt tolerance index, seedling vigour, germination percentage.**

INTRODUCTION

Mungbean (*Vigna radiata* L. Wilczek) is economically one of the most important pulse crops of *Vigna* gtroup and is cultivated since prehistoric period in India. It is grown throughout Asia, Australia, West Indies, South and North America, Tropical and sub-tropical Africa. India alone accounts for 65% of world acreage and 54% of world production. It is an important short duration grain legume having wider adaptability and low input requirements. Being rich in quality protein, minerals and vitamins, it is inseperable gradient in diets of vast majority of Indian population. When supplemented with cereals, it provides a perfect mix. of essential aminoacids with high biological value. Traditionally mungbean has been grown during *kharif* season. Development of short duration and disease resistant varieties has led its cultivation during spring/summer season in North and Central India and during winter (rice fallows) in the coastal peninsula. The yield is unstable both over locations and seasons due to susceptibility of cultivars to biotic and abiotic stresses. The productivity of this crop is drastically limited due to salt stress, one of the most appaling environmental factors. Because of continuous use of traditional methods of irrigation, the soils are subjected to salt concentration in the upper soil layer due to capillary rise and evaporation of salt water during dry season or from varying amount of salt in irrigation water, the sodicity impairs with various agronomic and physiological traits that reduces crop yield. Due to natural salinity and human interferences, the arable land is continuously transforming into saline that is expected to have overwhelming global effects and threats to world food supply (Saha *et al.*, 2010). Salinity stress cause severe changes in growth, physiology and metabolism of plants thus threatening the cultivation of plants around the globe (Lunde et.al., 2007). Salinity causesbreduction in growth, yield and quality of crops (Hasan et.al., 2017) as well as changes in plant metabolic process (Munns, 2002).

Saline stress is one of the main factors limiting legume productivity in arid and semi-arid regions (Luch et.al., 2007). Salinity adversely affects the plant growth and development. Seed germination (Dash and Panda, 2001); seed germination is usually the most critical stage in seedling establishment, determining successful crop production. Salinity stress creates potential problems during the seed germination and survival of seedlings. Mandal and Singh (2000) reported that salinity stress greatly varied the germination and seedling growth in different crop cultivars. It is a established fact that germination and early seedling stages of plant's life cycle is more sensitive to salinity than the adult stage. For the successful field establishment, good crop stand as well as higher yield, seeds should have the ability to germinate and proper seedling growth under salt stress. The superior performance regarding germination and seedling growth under salt stress has been used as a selection criterion for identifying salt tolerant genotypes. The present investigation, therefore, is an attempt to know the effect of salt stress on germination and early seedling growth of mungbean to find out the most salt tolerant genotype (s).

MATERIALS AND METHODS

The experimental materials comprised ten genetically diverse genotypes of mungbean (*Vigna radiata* L. Wilczek) of different geographic origin. The research work was carried out at Soil Salinity Farm, Dileep Nagar, Kanpur (U.P.). The sowing was done on 15 March 2019 in pots in completely randomized design (CRD) with 3 replications. The saline soils were collected from different fields (surface soil 0-15 cm depth) having exchangeable sodium percent (ESP) of 10, 20, 30 and 40 and kept for drying. After drying, the soils were thoroughly crushed and properly mixed. The earthen clay pots (10 kg soil capacity, 30 cm diameter and 30 cm height) which were lined their inner side by alkathene sheet to avoid leaching of salt were filled with soils of different ESP levels. The seeds of 10 mungbean genotypes were surface sterilized by dipping the seeds in 1% mercuric chloride solution for 2 minutes and rinsed thoroughly with sterilized water. Twenty seeds of each genotype were sown in each pot. The pot with soil with less than 6 ESP was considered as control. The daily weather data on temperature and humidity during experimental period were recorded. The temperature ranged from 32.4˚C to 36˚C and the average temperature was 33.7˚C during seed germination and seedling growth test. The minimum humidity of those days was 55% and maximum was 70%. The meteorological data on temperature and humidity are presented in Fig 1.

Germination was counted on tenth day of sowing and germination percentage was calculated using the following formula:

$$\text{Germination percentage} = \frac{\text{No. of seeds germinated}}{\text{No. of seeds placed for germination}} \times 100$$

Length of shoot and root of individual seedlings were recorded manually with scale. The mean lengths (cm) were calculated as per treatment combination. Shoot and root were weighed separately in fresh condition. The mean shoot and root fresh weight were calculated by total weight divided by the total number of seedlings. For determination of dry weight root and shoot were dried at 70˚C for 3 days in an oven (or till there is no decrease in weight). The mean and dry weights (mg) were calculated for each treatment combination. Vigour index was calculated by using the formula of Baki and Anderson (1973) as shown below:

Vigour index = Germination % x (mean shoot length + mean root length)

Salt tolerance index was calculated as (Goudarzi and Pakniyat, 2008) by the following formula

$$\text{Salt tolerance index} = \frac{variable\ measured\ under\ stress\ condition}{variable\ measured\ under\ normal\ condition}$$

The data were subjected to statistical analysis using standard formulae.

RESULTS AND DISCUSSION

The analysis of variance for the design of the experiment revealed significant differences among the genotypes and treatments for the traits under study indicating the existence of sufficient variability among the genotypes.

Germination percentage (%):

The GP varied from 72.56 to 90.63 under controlled condition, the highest being for KM 2241 and lowest for I 10 (Table 1& Fig.1). Salinity caused considerable reduction in seed germination and the genotypes showed dissimilar results with increasing salt stress. There was a considerable reduction in GP over control at 30 ESP level, the highest reduction (30.34%) was observed for Pusa Vishal and lowest (8.14%) for EC 88. At 40 ESP level, the percentage reduction in GP varied between 13.47 to 41.51. Looking at the percentage reduction at all ESP levels, it is evident that least reduction in GP was for EC 88 followed by KM 2241 at 10 ESP; EC 88 followed by I 51 at 20 ESP; EC 88 followed by I 10 at 30 ESP and EC 88 followed by I 10 at 40 ESP. EC 88 exhibited least reduction among the genotypes at all ESP levels indicating the considerable tolerance of this genotypes to salt stress. I 10 demonstrated its tolerance to salt at high ESP levels i.e. 30 and 40. The results are in conformily with those earlier reported by Sehrawat *et. al*. (2013) and Katiyar *et. al.* (2019) in mungbean. The progressive reduction in GP is due to inadequate supply of water resulting in low osmotic potential. Low water potential due to solute potential arised from salinity is a determining factor inhibiting the seed germination (Debez et. Al. 2004).

Shoot length:
The shoot length varied from 10.68 cm to 17.28 cm among the genotypes under controlled condition (Table 2). Salt stress reduced the length of shoot in all the genotypes. None of the genotypes showed its persistent performance with progressive increase in salinity stress. At 10 ESP, the least reduction in shoot length was observed for I 10 followed by Kopergaon; at 20 ESP, lowest reduction was of IPM 99-125 followed by I 10; at 30 ESP lowest reduction in shoot length was of KM 2241 followed by IPM 99-125 and at 40 ESP, the least reduction in shoot length was of KM 2241 followed by EC 88. At the high levels of ESP ie. 30 and 40, KM 2241 proved superior. The most common salinity effect was a general stunting of plant growth Mayer *et. al.* (1973) reported depression in different vital activities of plants, such as enzymes activities metabolism, cell division and photosynthesis under salt stress. The results are in agreement with those earlier reported by Pujol *et. al.* (2000) and Al-Seedi (2004) who observed that an increase in salinity induces delay in initiation of the germination process. Salinity deteriorated seed germination features at high NaCl osmotic potential during germination.

Root length:
Salinity stress significantly affected the root length in mungbean genotypes as compared to control (Table 2). Pusa Vishal, SML 668, I 51, I 10, Kopergaon and IPM 02-3 showed more than 20% reduction in root length whereas EC 88, Jalgaon, IPM 99-125 and KM 2241 less than 20% under moderate stress (20 EC). At high salt stress (40 ESP) all the genotypes reduced root length more than 40%. I 10 exhibited less than 40% root length reduction over control. None of the genotypes exhibited persistent performance for salt stress over increasing stress with respect to this trait. At 30 ESP, KM 2241 seemed better than other genotypes. Balasubramanian and Sinha (2006) also reported greater reduction of root length as compared to control due to salt stress. Salinity stress significantly reduced radical length by disturbing the absorption of water and nutrients from soil in roots (Muhammad and Majid, 2013).

Shoot fresh weight:
Shoot fresh weight varied from 2.55 mg to 5.42 mg among the genotypes in control condition. The shoot fresh reduced drastically with increasing level of salt stress (Table 3). This reduction was 33.71% to 51.35% under 10 ESP, 41.96% to 66.29% under 20 ESP: 50.19% to 70.91% under 30 ESP and 53.13% to 77.88% under 40 ESP. At moderate ESP (20), the least reduction was observed for EC 88 (41.96%). At high salt stress (40 ESP), the least reduction in shoot fresh weight was recorded in KM 2241 (53.13%). None of the genotypes exhibited persistent performance to maintain high shoot fresh weight with increasing level of salinity. The greatest shoot fresh weight of mungbean genotypes significantly reduced by salinity level of 40 ESP in all the genotypes. The highest reduction (77.88%) was found in Jalgaon. With increasing of salt stress from 4 to 20 EC progressively decreased the biomass of the roots and shoots in mungbean (Singh *et. al.*, 2011). The above results reconfirms the findings of Mohammed and Kramany (2005) in mungbean.

Root fresh weight:
Salt stress significantly inhibited the root fresh weight of 10 days old seedlings (Table 3). Under controlled condition root fresh weight varied from 0.72 mg to 1.61 mg among the genotypes, the highest being for KM 2241 and lowest for EC 88. At low salt stress condition (10 ESP) the lowest reduction in root fresh weight was observed of EC 88 (11.11%) and highest for KM 2241 (29.00%). At high salt stress (30 ESP and

40 ESP), more than 50% reduction was observed in all the genotypes. However, lowest reduction was observed in case of Pusa Vishal (68.05%). Looking at the overall picture, it appears that Pusa Vishal has better tolerance to increasing level of salt stress. The present results demonstrated that when the seeds were exposed to high salt stress, severe reduction in root length and root fresh weight appeared in all the genotypes. However, the genotypes having genetic potential for salt tolerance showed different behavior. The main reason of reducing the root fresh weight may be due to a decrease in water uptake by seedlings under saline condition. The root fresh weight showed greater variation in mungbean genotypes and salinity levels due to salt stress compared to control as has been reported by Kandil *et. al.* (2012). These results reconfirm the findings of Sehrawat *et. al.* (2013) in mungbean.

Shoot dry weight:
At low salt stress (10 ESP) more than 40%; at moderate stress (20 ESP) more than 50%; at 30 ESP level more than 60% and at 40 ESP level more than 70% reduction in shoot dry weight was observed in almost all the genotypes (Table 4). At 10 ESP level, IPM 02-3 followed by KM 2241, at 20 ESP, KM 2241followed by SML 668, at 30 ESP SML 668 followed by KM 2241 and at 40 ESP KM 2241 followed by IPM 99-125 exhibited better salt tolerance with almost lowest reduction in shoot dry weight, KM 2241 which is a farmer‘s' preferred variety in almost all the agro-climatic regions of the country demonstrated almost lowest reduction in shoot dry weight at all ESP levels indicting the stability of the variety with varying level of salt stress. Salt stress reduces the dry biomass as well as the rate of photosynthesis. The most common salinity affect is a general stunting pf plant growth. The standard reduction of seed germination, plant height, shoot and root length, dry matter, biomass were reduced in mungbean due to salinity stress as reported by Nafees et.al. (2010). The results are in conformity with those earlier reported by Singh *et. al.* (2011) in mungbean.

Root dry weight:
The root dry weight varied between 0.05 mg to 0.60 mg among the genotypes (Table 4), the highest being for KM 2241 and lowest for I 10. With the increasing intensity of salt stress, there had been considerable reduction in root dry weight in almost all the genotypes. At 10 ESP, the reduction in root dry weight was between 18.75% to 33.33%, the lowest was for I 10 and highest for KM 2241. At moderate intensity of salt stress ie. 20 ESP, the reduction in root dry weight was more than 40% in all the genotypes. At high salt stress (30 ESP) the reduction was more than 55% and at 40 ESP, the reduction was more than 65% in all the genotypes. At highest salt stress KM 2241 demonstrated the lowest reduction in root dry weight. IPM 99-125 exhibited lowest reduction at 10 ESP and 30 ESP and second lowest at 40 ESP. These genotypes seem to have genes for better tolerance to high intensity of salt stress. Gradual decrease of root dry weight with increasing salt concentrations were also noticed by Al-Seedi and Gattesh (2010) in mungbean. The present findings also agree with the findings of earlier workers Mohmaed and Kramany (2005) and Sehrawat *et. al.* (2013) in mungbean.

Seedlings vigour index:
Seedling vigour of mungbean was drastically reduced by salt stress (Table 1& Fig.2)). The reduction varied between 5.52% to 20.95% at 10 ESP; between 15.06% to 29.56% at 20 ESP; between 26.26% to 43.93% at 30 ESP and between 36.42% to 58.28% at 40 ESP. None of the genotypes exhibited persistent performance with respect to this trait, with increasing salt concentration. However, KM 2241 proved to be superior over other genotypes at moderate and high salt concentration IPM 99-125 was next in order. The lowest vigour index was noticed of I 51 genotype at all salinity levels. Kandil *et. al*. (2012) reported that increased NaCl stress decreased the seedling vigour of mungbean.

Salt tolerance index (STI) based on shoot dry weight:
Salt tolerance index (STI) based on shoot dry weight is depicted in Fig. 3. With the progressive increase in salt concentration there had been considerable decrease in salt tolerance. At 10 ESP, IPM 02-3 showed highest STI value (0.60) followed by KM 2241 and EC 88. At moderate salt concentration (20 ESP), highest STI value of 0.47 was observed for SML 668 followed by KM 2241, Pusa Vishal and Jalgaon. At 30 ESP, high value of STI was exhibited by Pusa Vishal followed by KM 2241. At high salt concentration KM 2241 exhibited highest salt tolerance followed by IPM 99-125 and I 51. KM 2241

a released cultivar, appeared to be a good genotype exhibited best salt tolerance at all the levels of ESP. Sayeed and Fatima (2011) reported that the salinity stress progressively reduced the salt concentration index in mungbean. The present results reconfirm the findings of Kausar et.al. (2012) in sorghum.

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Table 1. Germination and vigour index percentage of mungbean genotypes as influenced by salt stress

Genotype	Germination percentage					Vigour index (%)				
	Control	% reduction on 10 ESP	% reduction on 20 ESP	% reduction on 30 ESP	% reduction on 40 ESP	Control	% reduction on 10 ESP	% reduction on 20 ESP	% reduction on 30 ESP	% reduction on 40 ESP
Pusa vishal	86.67	6.18	16.17	30.34	41.51	1488	15.79	26.14	39.71	53.29
EC 88	82.24	2.55	6.09	8.14	13.47	2072	11.25	26.06	36.58	44.21
SML 668	84.72	4.00	13.16	19.51	25.33	1786	18.53	29.56	39.88	53.41
Jalgaon	81.86	8.19	16.61	21.36	24.89	1981	13.18	26.98	41.29	53.05
I 51	74.18	3.92	6.51	15.45	18.19	1532	20.95	29.43	38.51	58.28
IPM 99-125	80.50	3.66	9.67	21.45	19.80	1752	5.87	15.06	31.10	46.23
I – 10	72.56	4.02	7.17	10.18	14.78	1466	5.52	16.98	35.74	42.76
Kopergaon	78.35	3.56	10.44	15.08	18.41	1691	6.09	25.96	43.93	51.86

KM 2241	90.63	3.08	8.16	12.26	16.56	2448	6.33	16.46	26.26	36.42
IPM 02-3	82.23	4.27	10.51	15.30	17.48	1822	13.72	25.46	31.55	42.91

Table 2. Shoot length and Root length of mungbean genotypes as influenced by salt stress

Genotype	Shoot length (cm)					Root length (cm)				
	Control	% reduction on 10 ESP	% reduction on 20 ESP	% reduction on 30 ESP	% reduction on 40 ESP	Control	% reduction on 10 ESP	% reduction on 20 ESP	% reduction on 30 ESP	% reduction on 40 ESP
Pusa vishal	10.68	18.26	29.30	45.78	59.92	6.49	11.71	20.80	29.73	42.37
EC 88	15.19	12.96	32.91	38.44	43.25	10.01	8.69	15.68	33.76	45.65
SML 668	14.20	18.59	31.61	40.00	56.19	6.89	18.43	25.25	39.33	42.60
Jalgaon	14.57	13.58	32.18	45.64	54.83	9.64	12.65	18.98	34.75	53.11
I 51	11.84	22.56	30.57	35.39	54.05	8.81	18.73	27.81	42.67	63.90
IPM 99-125	12.31	6.74	14.21	32.81	41.99	9.46	0.52	16.17	28.85	51.69
I – 10	13.51	5.18	14.43	38.86	48.85	7.61	17.47	31.41	37.84	38.76
Kopergaon	14.01	6.20	24.98	45.32	52.03	7.61	5.91	27.98	41.65	51.77
KM 2241	17.28	6.53	17.36	28.76	38.94	9.73	5.96	14.79	21.79	44.38
IPM 02-3	13.30	15.11	28.32	34.51	43.76	8.08	7.67	20.66	26.61	41.46

Table 3. Shoot fresh and dry weight of mungbean genotypes as influenced by salt stress

Genotype	Shoot fresh weight (mg)					Shoot dry weight (mg)				
	Control	% reduction on 10 ESP	% reduction on 20 ESP	% reduction on 30 ESP	% reduction on 40 ESP	Control	% reduction on 10 ESP	% reduction on 20 ESP	% reduction on 30 ESP	% reduction on 40 ESP
Pusa Vishal	2.61	33.71	55.93	63.98	72.79	0.20	45.00	55.00	60.00	70.00
EC 88	2.55	40.39	41.96	50.19	60.39	0.19	42.10	57.89	63.15	73.68
SML 668	3.59	45.96	66.29	68.52	74.37	0.19	47.36	52.63	57.89	68.42
Jalgaon	4.16	48.31	60.57	70.91	77.88	0.22	45.45	54.54	63.63	72.72
I 51	2.96	51.35	58.10	68.58	76.01	0.21	47.61	57.14	61.90	66.67
IPM 99-125	4.26	35.50	48.82	60.32	74.88	0.18	44.44	55.55	61.11	66.66
I 10	3.10	40.32	59.35	70.64	73.22	0.21	47.61	57.14	66.66	71.42
Kopergaon	3.88	51.28	57.22	69.84	74.74	0.20	55.00	65.00	70.00	75.00
KM 2241	5.42	42.61	42.43	51.10	53.13	0.22	40.90	54.54	59.09	63.63
IPM 02-3	4.85	44.94	56.08	65.36	73.81	0.20	40.00	60.00	65.00	70.00

Table 4. Root fresh and dry weight of mungbean genotypes as influenced by salinity stress

Genotype	Root fresh weight (mg)					Root dry weight (mg)				
	Control	% reduction on 10 ESP	% reduction on 20 ESP	% reduction on 30 ESP	% reduction on 40 ESP	Control	% reduction on 10 ESP	% reduction on 20 ESP	% reduction on 30 ESP	% reduction on 40 ESP
Pusa Vishal	0.72	5.55	45.83	59.72	68.05	0.15	26.66	46.66	60.00	73.33

EC 88	0.54	11.11	40.74	61.11	74.07	0.08	25.00	50.00	62.50	75.00
SML 668	0.88	18.18	34.09	59.09	72.72	0.07	28.57	42.85	57.14	71.42
Jalgaon	1.10	18.18	41.81	61.81	72.72	0.14	21.42	42.85	57.14	71.42
I 51	0.96	15.62	34.41	60.41	72.91	0.05	20.00	40.00	60.00	80.00
IPM 99-125	1.00	14.00	29.00	67.00	77.00	0.16	18.75	43.75	56.25	68.75
I 10	0.63	19.04	41.26	58.73	74.60	0.05	20.00	40.00	60.00	80.00
Kopergaon	1.15	19.13	41.73	63.47	75.65	0.13	23.07	46.15	61.53	76.92
KM 2241	1.61	29.00	39.13	60.86	73.91	0.60	33.33	58.33	70.00	44.94
IPM 02-3	1.34	24.62	38.05	64.17	73.13	0.54	27.77	57.40	70.37	75.92

Table 5 : Salt tolerance index of mungbean genotypes based on shoot dry weight

Genotype	Salt tolerance index				
	Control	10 ESP	20 ESP	30 ESP	40 ESP
Pusa vishal	0.20	0.55	0.45	0.40	0.30
EC 88	0.19	0.58	0.42	0.36	0.26
SML 668	0.19	0.53	0.47	0.42	0.31
Jalgaon	0.22	0.54	0.45	0.36	0.27
I 51	0.21	0.52	0.43	0.38	0.33
IPM 99-125	0.18	0.56	0.44	0.38	0.33
I – 10	0.21	0.52	0.43	0.33	0.28
Kopergaon	0.20	0.45	0.35	0.30	0.25
KM 2241	0.22	0.59	0.45	0.40	0.36
IPM 02-3	0.20	0.60	0.40	0.35	0.30

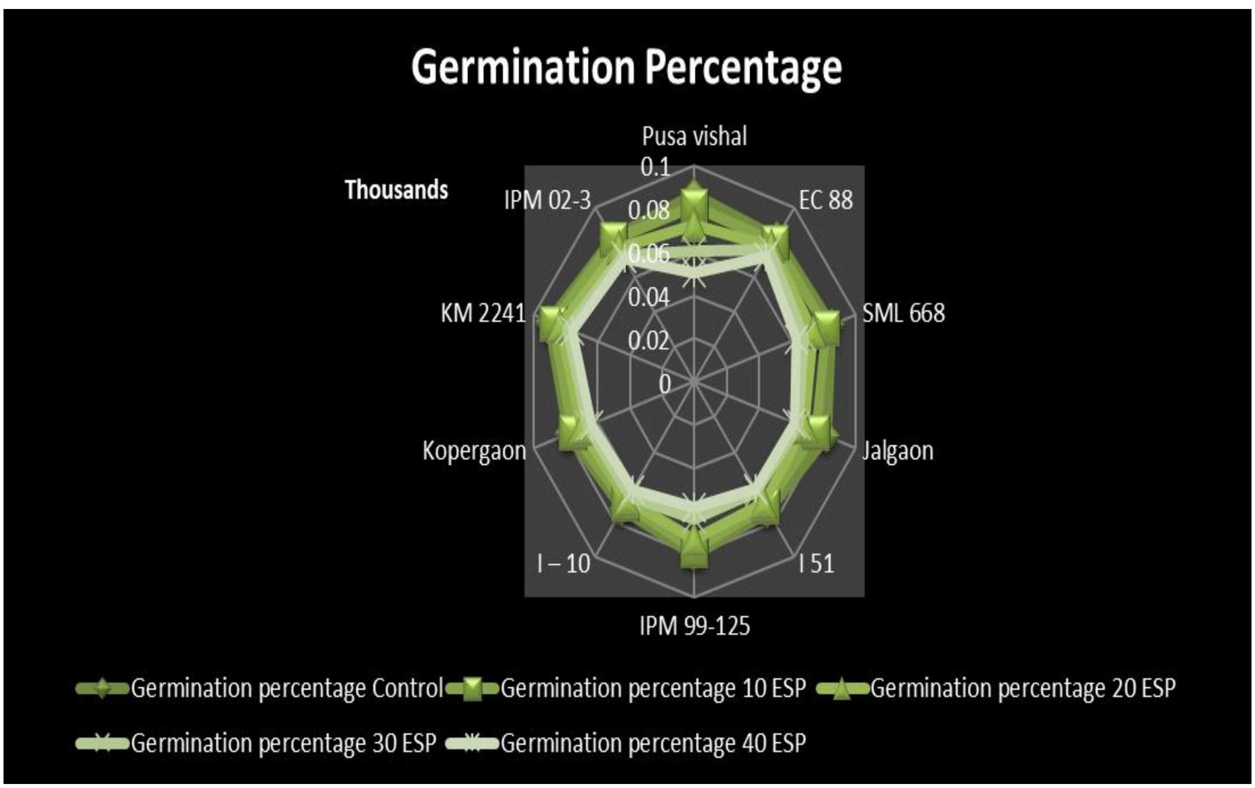

Fig1: Germination percentage of mungbean genotypes as influenced by different ESP over control

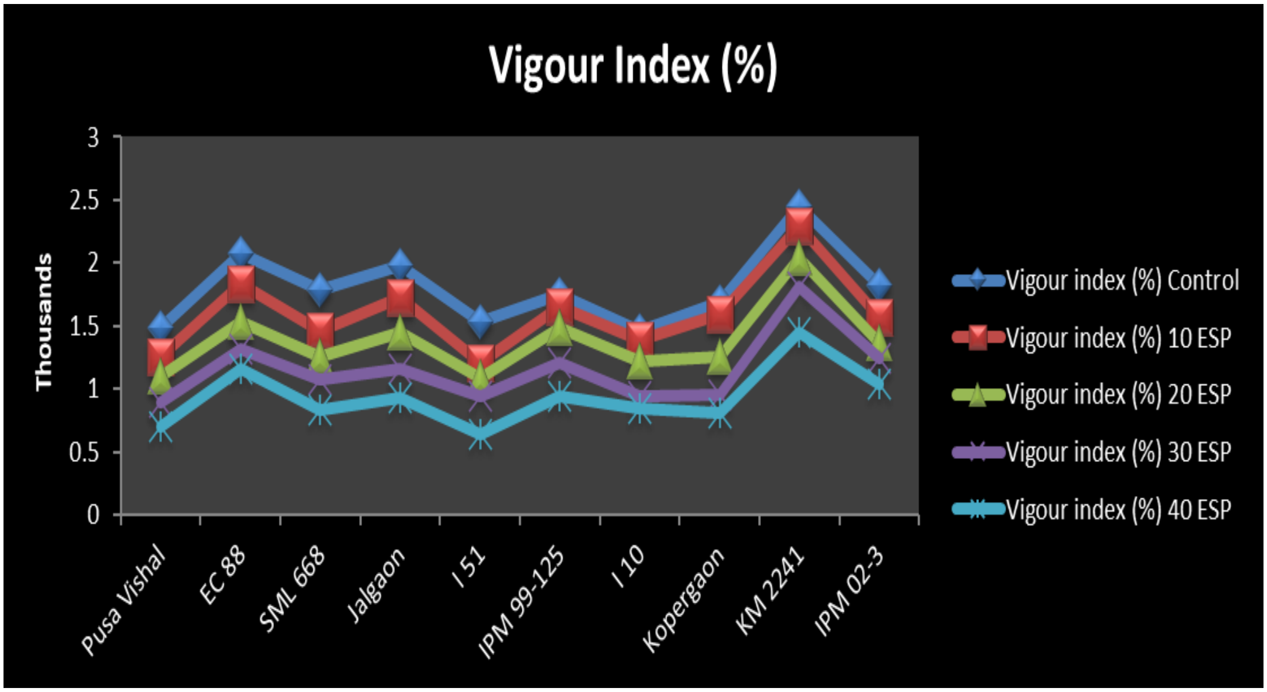

Fig2: Vigour index in percentage of mungbean genotypes as influenced by different ESP over control

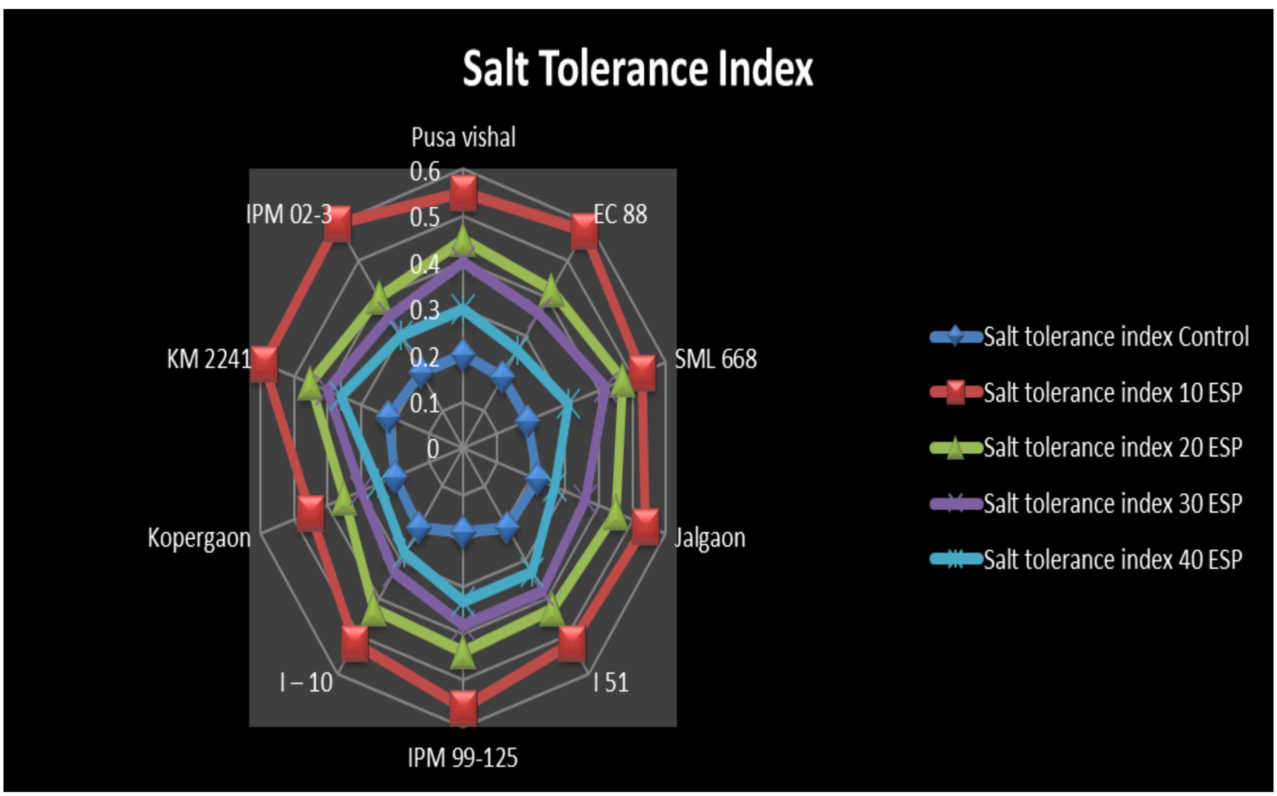

Fig3: Salt tolerance index in percentage of mungbean genotypes as influenced by different ESP over control