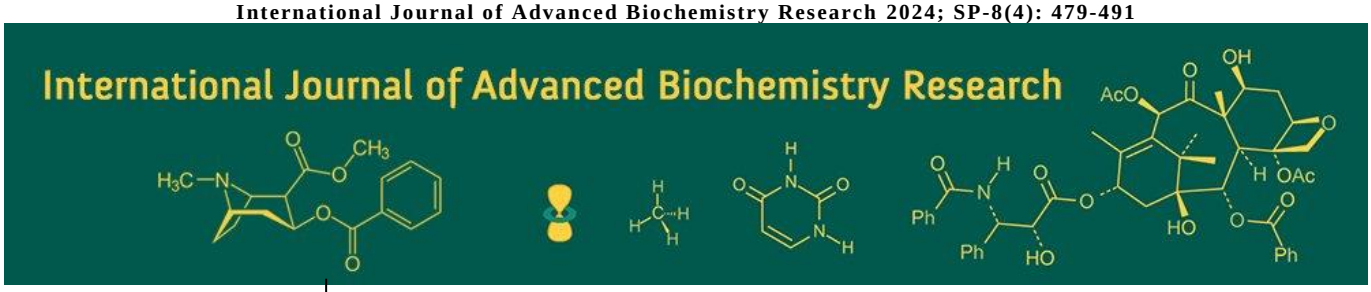

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Studies on effect of seed hydration value of various soybean varieties with respect to soil types and moisture regimes

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Abstract
The laboratory experiment was conducted in laboratory conditions during 2020-21 in Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani entitled "Studies on effect of seed hydration value of various soybean varieties with respect to soil types and moisture regimes" to evaluate the response of different soybean varieties in three soil types to three different soil moistures in laboratory conditions. This experiment was laid out in Factorial Completely Randomized Design with combinations of 72 treatments and three replications. This study was carried out in Petri plates with eight soybean varieties *viz*. MAUS-71, MAUS-158, MAUS-162, MAUS-612, JS-335, JS-9305, KDS-344 and KDS-726 at three moisture levels of 50%, 75% and 100% field capacities in three soil types i.e., Vertisols, Inceptisols and Entisols soils. The observations were taken at regular interval of time of 6 hours from sowing up to 96 hours. The results obtained from investigation indicated that various parameters like seed germination percentage and seed hydration value was influenced due to different soil moistures (field capacities) in different types of soils. Amongst all eight varieties, highest germination percentage was noted in MAUS-162 followed by MAUS-71 in three soil types and lowest germination percentage was recorded in JS-9305. In all three soil types, the highest seed hydration was recorded in MAUS-162 followed by KDS-726 and lowest seed hydration was noted in KDS-344 and MAUS-158 at three different moisture levels. Generally, varieties which showed low seed hydration value have low germination percentage but it is not applicable to all varieties as some seeds have thin seed coat while some have thick seed coat which affects the germination percentage of soybean. Amongst all three soil types, Vertisols and Inceptisols soil showed early and better germination for different varieties of soybean seeds. Also, better germination was observed in75% and 100% soil moistures. Among all eight soybean varieties, MAUS-158 and KDS-344 showed low seed hydration value than other varieties so they can be suitable for rainfed conditions. From investigation it was found that variety MAUS-162 was superior over all other varieties as it showed better germination percentage as well as highest seed hydration value.

Keywords: Germination percentage, germination, seed hydration, field capacity, moisture levels

1. Introduction
Soybean [*Glycine max* (L) Merill] is an important legume crop belonging to the family: Leguminosae, sub family: Papilionaceae and genus Glycine. The legumes are most valuable crop worldwide as a sustainable and alternative meat and are considered as the second most important food source after cereals. Among the modern agricultural commodities, soybean has prominent place as the world's most important seed legume, which contributes 25% of the global vegetable edible oil production and about two-thirds of the world's protein concentrate for livestock feeding. Nutritious food production is important which is achieved by 'Sustainable Development Goals Project'. Soybean belongs to legume family native to East Asia i.e., originated in China. The importance of soybean and its significant growth as a crop is because of the unique chemical composition of the bean, hence it is known as Golden Bean or Miracle crop, as they contain a complete source of 30-45% high quality protein with essential amino acids (5%) and 15-22% oil with favourable proportion of linoleic to linolenic acid. In consideration of its multiplicity of uses as food and industrial products, it is also called as a 'wonder crop' and 'boneless meat'. Soybean seeds also contains about 33% carbohydrates, up to 16.6% of which are soluble sugars.

AICRP on Soybean, Parbhani have developed new high yielding varieties of soybean having resistance to pests and diseases. It also undertook research work as per the need of cultivators of Marathwada region. There are various types of soybean varieties developed by AICRP in Parbhani *viz*., PARBHANI SONA (MAUS-47), PRATIKAR (MAUS-61), PRATISHTHA (MAUS-61-2), SAMRUDHI (MAUS-71), SHAKTI (MAUS-81), PRASAD (MAUS-32), Aarti (MAUS-1), POOJA (MAUS-2), MAUS-58 and MAUS-162 (Vasantrao Marathwada Krishi Veedyapeeth, Parbhani). There are various factors which affects the germination and emergence crop like moisture level in seed as well as in soil, soil conditions, temperature, oxygen, light, etc. These factors within the seed zone can affect soybean germination and emergence. Soybean germination begins with the seed imbibing (absorbing) approximately 50% of its weight in water followed by the development of the radicle (primary root) and emergence of the cotyledons (seed leaves). Planting into a moist seedbed with good seed-to-seed contact is important for optimal germination.

Soybean seeds comprises approximately 8% seed coat or hull, 90% cotyledons and 2% hypocotyl axis or germ. After planting, a soybean seed can begin to germinate when soil temperature is less than 55^0F. When soil temperatures are between 70^0F and 90^0F, seedling emergence should occur in less than a week. Soil temperature above 95^0F can also cause poor soybean germination and emergence resulting in reduced stands. A soybean seed will start to absorb water and swell after some time, resulting in a change in moisture content from less than 13% to almost 50% in several hours. Like most plants, soybeans grow in distinct morphological stages as they develop from seeds into fully mature plants. In soybean crop, the first stage of growth is germination, a method which first becomes apparent as a seed's radicle emerges. This is the first stage of root growth and occurs within the first 48 hrs. under ideal growing conditions. The first photosynthetic structure i.e., cotyledons developed from hypocotyl, the first plant structure to emerge from the soil. These cotyledons both act as leaves and as a source of nutrients for the immature plant, providing the seedling nutrition for its first 7 to 8 days. Germination and emergence are important issues for further growth stages and crop production. Early germination and better seedling establishment is very crucial for oil seed production. Like with all crops, the seasonal water usage of soybeans is determined by the atmospheric demand and the availability of water in the soil profile. If the evaporation demand is to exceed the supply of water (rain or irrigation), soybeans will only use the water readily available. The water use efficiency of soybeans varies between 4 kg and 7 kg of grain per hectare per mm water usage. The water usage of soybeans is affected by the weather conditions as well as by the growth stage of the plant. Factors take into account are the weather conditions, type of soil, growth stage of the plant, growth period, plant population, mulch and minimum tillage, etc. The water requirement of soybeans will vary throughout the season according to the weather conditions and the growth stage of the plant, which requires more or less water. So, knowledge regarding soybeans water requirements ensures better irrigation scheduling and also enables the producer to make the right cultivar choice where dryland cultivation is concerned. There are different types of soils vary in how much water content they can hold and how tightly they hold as the soil dries in various seasons. The seed germination and plant growth depend on how tightly the water is being held and not by how much water content in the soil. This shows that measuring of how much moisture content in soil does not tell us to predict whether a seed will germinate or not. For this purpose, three types of soils were collected from different places i.e., Vertisols, Inceptisols and Entisols. The best soybean yields occur on well-drained, but not sandy, soils having a pH of 6.5 or above. Seed germination was greatly influenced by soil texture, foremost silt percentage and soil pH. There was a positive correlation among germination percentage, silt content and soil pH. Seed Priming treatment has beneficial effects on the vigor and viability of seeds which is manifested by improved germination performance and seedling growth especially under adverse environmental conditions. Seed priming involves taking seed through the early stages of the germination process. The technique which involves controlled seed hydration sufficient to permit germinative metabolic events to proceed, but insufficient to allow radicle protrusion (Lutts *et al*. 2016) [13]. Moisture level is an important factor of every crop that it directly related with the germination percentage of that particular crop. So, moisture stress condition definitely an inference to agriculture by its influence on germination and seedling growth of seed. Genetic makeup also has significant impact on seed germination and other growth and yield parameters of crop species and also there are not many details on moisture absorption characteristics of soybean seed varieties. Therefore, in this experiment eight released varieties will be testes in three different moisture level conditions in three types of soil.

2. Materials and Methods

The present experiment was done for studying the effect of moisture levels on seed germination and seed hydration value for germination in eight different varieties of soybean in three types of soils in Parbhani district of Maharashtra state. The results of study will evaluate that which soybean variety was suitable for the particular region and climatic condition. Hence, accordingly the study was planned. In this chapter, all material and methods followed during the study of this experiment are presented below. For this experiment, three different types of soil were selected and these soils were collected from following three locations.

1. **Vertisols:** Research farm of AICRP on soybean Research station, VNMKV, Parbhani
2. **Inceptisols:** Research field of AICRP on dryland, VNMKV, Parbhani
3. **Entisols:** Research farm of College of Food Technology, VNMKV, Parbhani

Table 1: Physical and chemical properties of soils selected for experiment

Sr. No.	Parameters	Units	Soil types		
			Vertisols	Inceptisols	Entisols
1.	pH		7.3	7	7.1
2.	EC	dSm^{-1}	0.46	0.24	0.66
3.	Organic carbon	%	0.97	0.67	0.61
4.	Calcium carbonate	%	4.5	6.3	11.6

The laboratory experiment was carried out in the PG laboratory of Department of Soil Science and Agricultural Chemistry in Parbhani during 2021-22 using eight varieties

of soybean with 3 different soil orders and three moisture levels in Petri dishes. Seed hydration value of different eight varieties were calculated using water absorption by seed and germination related parameters. The representative soil samples were collected at a depth of 0 to 30 cm from respective locations of each type of soil and a composite sample was analyzed for studying the different physical and chemical properties of soils. The experiment was carried out by using Petri plates of medium size in which 75 gm soil was taken for total 72 treatments with eight varieties of soybean and three moisture levels having 50%, 75% and 100% field capacity in three types of soils. These 72 treatments were replicated three times under laboratory conditions. Three types of soils were collected from three different suitable places in Marathwada region at a depth of 0 to 30 cm surface layer. Firstly, sieved the soil by 2 mm sieve for the conducting experiment and these soil samples are also used for the determination of chemical and physical properties of soils. First of all, wash the Petri plates properly with tap water and then with distilled water. The processed 2 mm soil samples were poured in Petri plates and levelled it by tapping multiple times. Soil inside Petri plate was levelled in all 72 treatments. The soil moisture was maintained in all Petri plates. Good quality and viable soybean seeds of eight varieties are selected for sowing purpose. The seeds having good physical properties such as uniform size, shape, color and high genetic purity with good germination ability are used. 10 seeds were selected for sowing in a single Petri plate and sowing was done by dibbling method in all Petri plates equidistantly. The germination of seed from every treatment were counted and expressed in percentage. In this experiment, 10 seeds of varieties were taken and measure its dry weight by using weighing balance. The weight was taken in milligrams. These seeds are sown equidistantly in 72 Petri plates and these are covered by glass to avoid moisture loss due to evaporation. These seed were allowed to remain till germination. The observations were taken at regular time interval of 6 hours up to 96 hours. The weight of germinated seeds was also taken in milligrams and germination percentage were expressed in percentage. Seed index was calculated by taking weight of 100 seeds of each variety. Average weight of 10 seeds was calculated before sowing and weight of germinated seeds was also taken at regular time interval of 6 hours for 4 days means up to 96 hours. Seed hydration was calculated by taking difference between weight of wet seed at observation time and weight of dry seed at initial for each variety of soybean. The observations of germinated seeds were taken at regular interval and counted the germinated seeds of each variety. Then germination percentage was calculated.

3. Results and Discussion

3.1 Time required for germination in soybean varieties at different moisture levels in Vertisols soil

The data presented in Table 2 represents the germination of eight different soybean varieties at three moisture levels in Vertisols at regular time interval of 6 hours and it indicated that germination of seeds takes place at 24 hours in all three moisture levels while KDS-726 shows early germination before 24 hours in 100% moisture level. Number of germinated seeds were less at 50% field capacity than 75% and 100% field capacity. The highest number of seed germination count was at 100% field capacity. Maximum germination count was occurred in between 42 to 48 hours in which all varieties show at least one seed germinated and better germination recorded in variety MAUS-162 at 75% and 100% field capacity followed by MAUS-71 and KDS-726. Minimum germination was observed in JS-9305 followed by JS-335 variety having 30 to 40% germination which is less than all other varieties. There were no seed germinated after 78 hours.

3.2 Effect of different soil moisture levels on germination percentage of soybean varieties in Vertisols soil

The data revealed from Table 3 represents the germination percentage for eight soybean varieties that are MAUS-71, MAUS-158, MAUS-162, MAUS-612, JS-335, JS-9305, KDS-344 and KDS-726 and three moisture levels i.e., 50%.75% and 100% field capacity of soil moisture in Vertisols and the data recorded from this table was significant and it showed the maximum germination percentage was recorded at M_3-100% field capacity (80.87%) followed by M_2-75% field capacity (74.50%) while minimum germination was recorded at M_1-50% field capacity (55.75%). In this case, the germination percentage in eight different varieties also showed significant effect of moisture levels and maximum germination percentage was showed by variety MAUS-162 (85.67%) followed by MAUS-71 (79.67%) and minimum germination percentage was showed by variety JS-9305 (58%).

The result recorded in all varieties was significant for germination of seeds in Vertisols soil. The interaction effect of different soybean varieties and three moisture levels were showed in Table 4. Interaction showed the highest germination i.e., 97% was recorded in V_3 (MAUS-162) x M_3 (100% field capacity) which is followed by interaction V_3 (MAUS-162) x M_2 (75% field capacity) having 90% germination. The minimum germination percentage was observed in V_6 (JS-9305) x M_1 (50% field capacity) having germination percentage 43%. Similar result was noted by Dhama (2021) [4] and Jajoria (2017) [7] in which variety MAUS-162 showed maximum germination percentage i.e., 100% while MAUS-158 shows minimum germination percentage in their study. In this laboratory experiment, JS-9305 variety showed minimum germination percentage i.e., 43% followed by MAUS-158 and JS-335 having germination percentage of 45% in both varieties. It indicates that, JS-9305 requires more moisture than 100% field capacity and also it was a slow germinating variety.

From this study, it was concluded that 100%, 75% and 50% field capacity is suitable for variety MAUS-162 as it shows highest germination percentage in all three moisture levels of field capacities in Vertisols soil and performed early and better seed germination.

Table 2: Time required for germination in soybean varieties at different moisture levels in Vertisols soil

Sr. No.	Varieties	Time (hrs.)												Germinated seeds	Germination %
		6-18	18-24	24-30	30-36	36-42	42-48	48-54	54-60	60-66	66-72	72-78	78-96		
		Germination at 50% field capacity in Vertisols													
1.	MAUS-71	-	-	2	-	-	1	2	-	-	1	-	-	6	60
2.	MAUS-158	-	-	-	-	1	1	1	-	-	1	-	-	4	40
3.	MAUS-162	-	-	3	2	-	1	1	-	-	-	-	-	7	70
4.	MAUS-612	-	1	-	2	-	1	-	1	-	1	-	-	6	60
5.	JS-335	-	-	-	-	-	1	1	-	1	-	-	-	3	30
6.	JS-9305	-	-	-	-	-	1	-	1	1	-	-	-	3	30
7.	KDS-344	-	-	-	-	1	1	1	-	1	-	1	-	5	50
8.	KDS-726	-	-	1	2	-	1	1	-	-	-	-	-	5	50
		Germination at 75% field capacity in Vertisols													
1.	MAUS-71	-	-	4	1	-	1	-	2	-	-	-	-	8	80
2.	MAUS-158	-	-	-	-	1	-	1	2	1	1	-	-	6	60
3.	MAUS-162	-	2	2	1	-	1	1	2	-	-	-	-	9	90
4.	MAUS-612	-	-	2	-	1	2	1	-	1	-	-	-	7	70
5.	JS-335	-	-	-	-	1	2	1	-	1	-	-	-	5	50
6.	JS-9305	-	-	-	-	1	1	-	-	1	1	-	-	4	40
7.	KDS-344	-	-	-	-	-	1	1	2	-	1	1	-	6	60
8.	KDS-726	-	2	1	-	1	2	-	1	-	-	-	-	7	70
		Germination at 100% field capacity in Vertisols													
1.	MAUS-71	-	-	1	-	1	2	2	1	1	-	-	-	8	80
2.	MAUS-158	-	-	-	-	-	1	2	1	2	1	-	-	7	70
3.	MAUS-162	-	2	2	1	-	1	2	-	1	-	-	-	9	90
4.	MAUS-612	-	-	2	1	-	2	1	-	1	1	-	-	8	80
5.	JS-335	-	-	-	-	1	2	2	1	1	-	-	-	7	70
6.	JS-9305	-	-	-	-	2	1	-	2	-	1	1	-	7	70
7.	KDS-344	-	-	-	-	1	2	-	1	2	1	-	-	7	70
8.	KDS-726	-	2	1	-	1	3	-	1	-	-	-	-	8	80

Table 3: Effect of different soil moisture levels on germination percentage of soybean varieties in Vertisols soil

Treatments	Germination%
Moisture	
M1-50% FC	55.75
M2-75% FC	74.50
M3-100% FC	80.87
S.Em.	2.35
C.D. at 5%	6.91
Varieties	
V1-MAUS-71	79.67
V2-MAUS-158	62.67
V3-MAUS-162	85.67
V4-MAUS-612	77.33
V5-JS-335	61.67
V6-JS-9305	58
V7-KDS-344	66.33
V8-KDS-726	71.67
S.Em.	3.15
C.D. at 5%	9.36
Interaction	
S.Em.	2.88
C.D. at 5%	8.47

Table 4: Interaction effect of eight soybean varieties and three different soil moisture levels on germination percentage in Vertisols soil

Treatments	V1-MAUS-71	V2-MAUS-158	V3-MAUS-162	V4-MAUS-612	V5-JS-335	V6-JS-9305	V7-KDS-344	V8-KDS-726	Mean M (Moisture)
M1-50% FC	68	45	70	65	45	43	52	58	55.75
M2-75% FC	87	65	90	85	65	60	68	76	74.50
M3-100% FC	84	78	97	82	75	71	71	81	80.87
Mean V (Variety)	79.67	62.67	85.67	77.33	61.67	58	66.33	71.67	
Interaction	M	V	M X V						
S.Em.	2.35	3.15	2.88						
C.D. at 5%	6.91	9.36	8.47						

3.3 Time required for germination in soybean varieties at different moisture levels in Inceptisols soil

The data presented in Table 5 depicts the germination percentage of eight different soybean varieties at three different field capacities i.e., 50%, 75% and 100% in Inceptisols at regular time interval of 6 hours after sowing and maximum germination was observed at 36 to 48 hours and after 78 hours, there were no germination of seeds. The result indicated in Table 5, nearly similar germination was observed at all three soil moisture at field capacities. The highest number of seed germination is at 100% field capacity. Early and better germination was recorded in variety MAUS-162 followed by MAUS-71 and KDS-726 at all three soil moisture levels at field capacities. Maximum and earlier germination was recorded in MAUS-162 and KDS-726 in 75% and 100% field capacity. Lowest germination was observed in JS-9305 variety.

Table 5: Time required for germination in soybean varieties at different moisture levels in Inceptisols soil

Sr. No.	Varieties	Time (hrs.)												Germinated seeds	Germination%
		6-18	18-24	24-30	30-36	36-42	42-48	48-54	54-60	60-66	66-72	72-78	78-96		
		Germination at 50% field capacity in Inceptisols													
1.	MAUS-71	-	-	1	-	2	1	-	1	-	1	-	-	6	60
2.	MAUS-158	-	-	-	-	-	1	-	1	-	1	1	-	4	40
3.	MAUS-162	-	-	-	1	1	4	-	-	1	-	-	-	8	80
4.	MAUS-612	-	-	-	2	1	1	-	1	-	1	-	-	6	60
5.	JS-335	-	-	-	-	-	1	1	-	1	-	-	-	3	30
6.	JS-9305	-	-	-	-	1	-	1	-	1	-	-	-	3	30
7.	KDS-344	-	-	-	-	1	1	-	2	-	1	-	-	5	50
8.	KDS-726	-	-	2	-	1	2	-	1	-	-	-	-	6	60
		Germination at 75% field capacity in Inceptisols													
1.	MAUS-71	-	1	2	1	1	-	-	1	1	-	-	-	7	70
2.	MAUS-158	-	-	-	-	-	-	1	2	2	1	-	-	6	60
3.	MAUS-162	-	2	3	1	-	2	-	-	-	-	-	-	8	80
4.	MAUS-612	-	-	-	2	1	1	-	1	1	-	1	-	7	70
5.	JS-335	-	-	-	1	-	-	2	1	1	-	-	-	5	50
6.	JS-9305	-	-	-	-	1	1	-	1	-	1	-	-	4	40
7.	KDS-344	-	-	-	1	-	1	2	-	1	-	1	-	6	60
8.	KDS-726	-	2	-	3	-	1	-	1	-	-	-	-	7	70
		Germination at 100% field capacity in Inceptisols													
1.	MAUS-71	-	-	-	2	2	1	1	1	1	-	-	-	8	80
2.	MAUS-158	-	-	-	1	1	-	1	2	2	-	-	-	7	70
3.	MAUS-162	-	2	2	1	1	1	1	1	-	-	-	-	9	90
4.	MAUS-612	-	-	1	1	2	-	2	-	1	-	1	-	8	80
5.	JS-335	-	-	-	-	1	2	1	2	1	-	-	-	7	70
6.	JS-9305	-	-	-	-	1	1	1	2	-	1	-	1	7	70
7.	KDS-344	-	-	-	1	-	2	2	-	1	-	1	-	7	70
8.	KDS-726	-	2	1	-	2	1	-	1	-	-	-	-	7	70

Table 6: Effect of different soil moisture levels on germination percentage of soybean varieties in Inceptisols soil

Treatments	Germination%
Moisture	
M1-50% FC	51.75
M2-75% FC	70.62
M3-100% FC	80.25
S.Em.	3.56
C.D. at 5%	9.95
Varieties	
V1-MAUS-71	78.33
V2-MAUS-158	60.33
V3-MAUS-162	78.33
V4-MAUS-612	75.67
V5-JS-335	57.67
V6-JS-9305	55
V7-KDS-344	65.33
V8-KDS-726	69.67
S.Em.	3.17
C.D. at 5%	9.31
Interaction	
S.Em.	3.11
C.D. at 5%	9.14

3.4 Effect of different soil moisture levels on germination percentage of soybean varieties in Inceptisols soil

Effect of different moisture levels on germination percentage of soybean varieties in Inceptisols soil was revealed from Table 6 and it represents the germination percentage for eight soybean varieties that are MAUS-71, MAUS-158, MAUS-162, MAUS-612, JS-335, JS-9305, KDS-344 and KDS-726 and three moisture levels i.e., 50%.75% and 100% field capacity of soil moisture in Inceptisols soil and the data from this table was found significant and shows the maximum germination percentage at M_3-100 field capacity (80.25%) followed by M_2-75% field capacity (70.62%) while minimum germination was recorded at M_1-50% field capacity (51.75%). It showed that soil moisture is an important factor for gemination of seeds in Inceptisols soil as it shows better result at 100% field capacity than 75% field capacity. The germination percentage in eight different varieties also showed significant effect of moisture levels and maximum germination percentage was showed by variety MAUS-162 and MAUS-71 having germination percentage of 78.33% in both varieties followed by MAUS-612 (75.67%) and minimum germination percentage was showed by variety JS-9305 (55%).

The interaction effect of soybean varieties and moisture levels on germination of soybean seeds in Inceptisols soil influenced significant result. The data presented in Table 7 showed that maximum germination was observed in many interactions i.e., V_3 (MAUS-162) x M_3 (100% field capacity), V_3 (MAUS-162) x M_2 (75% field capacity), V_1 (MAUS-71) x M_3 (100% field capacity) and V_1 (MAUS-71) x M_2 (75% field capacity) having germination percentage 85% while minimum germination was observed in V_6 (JS-9305) x M_1 (50% field capacity) having germination percentage of 38%. Similar findings were observed by Fawusi and Agboola (1980) [23] that seeds were not germinated in Celosia under little shortage of moisture. Similar findings were also observed in tomato, sorghum and millets. Celosia needs 75% field capacity for better germination of seeds while tomato needed 50 to 75% field capacity for good germination of tomato seeds. In similar way, Malik *et al.* (2004) [24] was also found that germination of seeds in two cultivars of *Pennisetum amaricanum* L. was highest at moderate soil moisture levels while minimum germination was observed in lower and higher soil moisture levels.

Table 7: Interaction effect of eight soybean varieties and three different soil moisture levels on germination percentage in Inceptisols soil

Treatments	V1-MAUS-71	V2-MAUS-158	V3-MAUS-162	V4-MAUS-612	V5-JS-335	V6-JS-9305	V7-KDS-344	V8-KDS-726	Mean M (Moisture)
M1-50% FC	65	42	65	62	40	38	48	54	51.75
M2-75% FC	85	62	85	81	55	52	70	75	70.62
M3-100% FC	85	77	85	84	78	75	78	80	80.25
Mean V (Variety)	78.33	60.33	78.33	75.67	57.67	55	65.33	69.67	
Interaction	M	V	M X V						
S.Em.	3.56	3.17	3.11						
C.D. at 5%	9.95	9.31	9.14						

Table 8: Time required for germination in soybean varieties at different moisture levels in Entisols soil

Sr. No.	Varieties	Time (hrs.)												Germinated seeds	Germination %
		6-18	18-24	24-30	30-36	36-42	42-48	48-54	54-60	60-66	66-72	72-78	78-96		
		Germination at 50% field capacity in Entisols													
1.	MAUS-71	-	-	-	-	1	1	1	-	1	-	1	-	5	50
2.	MAUS-158	-	-	-	-	-	1	1	1	1	-	-	-	4	40
3.	MAUS-162	-	-	-	-	1	2	-	2	-	1	-	-	6	60
4.	MAUS-612	-	-	-	-	1	1	-	1	-	1	1	-	5	50
5.	JS-335	-	-	-	-	-	1	1	-	-	1	-	-	3	30
6.	JS-9305	-	-	-	-	-	1	-	1	-	-	-	-	2	20
7.	KDS-344	-	-	-	-	1	-	1	-	1	1	-	-	4	40
8.	KDS-726	-	-	-	1	-	2	1	-	1	-	-	-	5	50
		Germination at 75% field capacity in Entisols													
1.	MAUS-71	-	-	-	2	1	1	-	1	1	1	-	-	7	70
2.	MAUS-158	-	-	-	-	-	2	1	-	1	-	-	2	6	60
3.	MAUS-162	-	1	1	2	1	-	-	1	-	-	1	-	7	70
4.	MAUS-612	-	-	-	1	-	2	1	-	1	1	-	-	6	60
5.	JS-335	-	-	-	-	-	1	2	1	1	-	-	-	5	50
6.	JS-9305	-	-	-	-	-	1	1	-	1	-	1	-	4	40
7.	KDS-344	-	-	-	-	-	1	2	-	1	1	-	-	5	50
8.	KDS-726	-	-	-	2	1	2	-	1	-	-	-	-	6	60
		Germination at 100% field capacity in Entisols													
1.	MAUS-71	-	1	3	-	1	1	1	1	-	1	-	-	9	90
2.	MAUS-158	-	-	-	-	-	2	1	2	1	1	-	-	7	70
3.	MAUS-162	-	-	2	-	1	1	2	1	1	1	-	-	9	90
4.	MAUS-612	-	-	-	2	-	1	1	2	1	-	1	-	8	80
5.	JS-335	-	-	-	-	-	2	1	2	1	1	-	-	7	70
6.	JS-9305	-	-	-	-	-	1	2	1	1	1	-	1	7	70
7.	KDS-344	-	-	-	-	1	1	1	-	2	-	1	1	7	70
8.	KDS-726	-	-	2	1	-	2	1	1	1	-	-	-	8	80

Time required for germination in soybean varieties at different moisture levels in Entisols soil

The data described in Table 8 depicts the germination of eight different soybean varieties at three different soil moisture at field capacities i.e., 50%, 75% and 100% in Entisols at regular time interval of 6 hours after sowing and maximum germination was occurred at 42 to 48 hours and no any germination of seeds was noted after 78 hours. From the result it was observed that in Table 8, nearly similar germination was observed at all three soil moistures at field capacities with minute difference in time interval of germination. The highest number of seed germination is at 100% field capacity followed by 75% and 50%. Maximum germination was occurred in between 42 to 48 hours and earlier germination was observed in MAUS-162 and MAUS-71 in 100% soil moisture at field capacity. Earlier germination was recorded in variety MAUS-162 and also in MAUS-71 and KDS-726. Minimum germination was observed in JS-9305 variety.

3.6 Effect of different soil moisture levels on germination percentage of soybean varieties in Entisols soil: Effect of different moisture levels on germination percentage of soybean varieties in Entisols soil was revealed

from Table 9 and it represents the germination percentage for eight soybean varieties that are MAUS-71, MAUS-158, MAUS-162, MAUS-612, JS-335, JS-9305, KDS-344 and KDS-726 and three moisture levels i.e., 50%, 75% and 100% soil moisture at field capacity of soil in Entisols type of soil. The data from this table was found significant and it shows the maximum germination percentage was recorded at M_3-100% field capacity (78.87%) followed by M_2-75% soil moisture at field capacity (64.62%) while minimum germination was recorded at M_1-50% soil moisture at field capacity (46%). The germination percentage in eight different varieties also showed significant effect of moisture levels and maximum germination percentage was recorded by variety MAUS-162 (73.67%) followed by MAUS-71 (72.67%) and minimum germination percentage was counted by variety JS-9305 (51%) followed by JS-335 (54.33%).

The interaction effect of moisture levels and soybean varieties on germination of soybean seeds in Entisols soil showed significant result. The data presented in Table 10 recorded that maximum germination was observed in interactions V_1 (MAUS-71) x M_3 (100% field capacity) having value 83% followed by V_3 (MAUS-162) x M_3 (100% field capacity) having germination of 81% and interactions V_3 (MAUS-162) x M_2 (75% field capacity) and V_1 (MAUS-71) x M_2 (75% field capacity) with values 80% for each interaction. While minimum germination was observed in V_6 (JS-9305) x M_1 (50% field capacity) having 33% germination. Collis-George and Hector (1966) studied matric potential and wetted area of contact are deciding factors for germination of seed. Also, the matric potential having its positive effect on checking the wetted contact area between medium and seed. Thus, Entisols soil requires less seed-soil contact area for germination of seed.

Table 9: Effect of different soil moisture levels on germination percentage of soybean varieties in Entisols soil

Treatments	Germination%
Moisture	
M1-50% FC	46
M2-75% FC	64.62
M3-100% FC	78.87
S.Em.	2.43
C.D. at 5%	7.25
Varieties	
V1-MAUS-71	72.67
V2-MAUS-158	58.33
V3-MAUS-162	73.67
V4-MAUS-612	69
V5-JS-335	54.33
V6-JS-9305	51
V7-KDS-344	61.67
V8-KDS-726	64.67
S.Em.	3.21
C.D. at 5%	9.52
Interaction	
S.Em.	2.85
C.D. at 5%	8.47

Table 10: Interaction effect of eight soybean varieties and three different soil moisture levels on germination percentage in Entisols soil

Treatments	V1-MAUS-71	V2-MAUS-158	V3-MAUS-162	V4-MAUS-612	V5-JS-335	V6-JS-9305	V7-KDS-344	V8-KDS-726	Mean M (Moisture)
M1-50% FC	55	40	60	52	35	33	45	48	46
M2-75% FC	80	58	80	75	50	45	62	67	64.62
M3-100% FC	83	77	81	80	78	75	78	79	78.87
Mean V (Variety)	72.67	58.33	73.67	69	54.33	51	61.67	64.67	
Interaction	M	V	M X V						
S.Em.	2.43	3.21	2.85						
C.D. at 5%	7.25	9.52	8.47						

3.7 Time of water absorption required for germination in soybean varieties at different moisture levels in Vertisols soil

The data from Table 11 depicts that time required for water absorption or seed hydration of germinated wet seeds in three different soil moisture levels i.e., 50%, 75% and 100% at different time interval in Vertisols soil. The time required for water absorption vary according to different varieties of soybean seeds. Among all eight varieties, MAUS-162 and MAUS-71 shows early seed hydration than other varieties. More seed hydration value for germination at all three soil moisture at field capacities was reported in time interval of 42 to 48 hours. After 54 hours, there were no seed hydration took place.

3.8 Effect of different moisture levels on seed hydration value of soybean varieties in Vertisols soil

The data presented in Table 12 observed that the effect of different moisture levels on seed hydration value in soybean varieties at three different soil moisture at field capacities. The significant result was observed in Vertisols soil with respect to seed hydration value or water absorption by seeds. The highest seed hydration value was observed at 100% field capacity i.e., M_3-100% is 0.147 grams followed by M_2-75% and M_1-50%.

Table 11: Water absorption in different soil moisture at the time of germination by soybean varieties in Vertisols soil

Sr. No.	Varieties	Time (hrs.)												Wet seed wt. (g/seed)	Dry seed wt. (g/seed)	Seed Hydration
		6-18	18-24	24-30	30-36	36-42	42-48	48-54	54-60	60-66	66-72	72-78	78-96			
		Germination at 50% field capacity in Vertisols														
1.	MAUS-71	-	-	0.63 (2)	-	-	0.32 (1)	0.65 (2)	-	-	0.34 (1)	-	-	0.323	0.166	0.157
2.	MAUS-158	-	-	-	-	0.28 (1)	0.29 (1)	0.31 (1)	-	-	0.30 (1)	-	-	0.295	0.153	0.142
3.	MAUS-162	-	-	0.89 (3)	0.58 (2)	-	0.27 (1)	0.29 (1)	-	-	-	-	-	0.290	0.118	0.172
4.	MAUS-612	-	0.27 (1)	-	0.54 (2)	-	0.29 (1)	-	0.31 (1)	-	0.32 (1)	-	-	0.288	0.150	0.138
5.	JS-335	-	-	-	-	-	0.29 (1)	0.27 (1)	-	0.28 (1)	-	-	-	0.280	0.170	0.110
6.	JS-9305	-	-	-	-	-	0.33 (1)	-	0.36 (1)	0.37 (1)	-	-	-	0.353	0.185	0.168
7.	KDS-344	-	-	-	-	0.26 (1)	0.27 (1)	0.29 (1)	-	0.28 (1)	-	0.27 (1)	-	0.274	0.138	0.136
8.	KDS-726	-	-	0.29 (1)	0.58 (2)	-	0.31 (1)	0.33 (1)	-	-	-	-	-	0.302	0.128	0.174
		Germination at 75% field capacity in Vertisols														
1.	MAUS-71	-	-	1.04 (4)	0.29 (1)	-	0.32 (1)	-	0.62 (2)	-	-	-	-	0.284	0.113	0.171
2.	MAUS-158	-	-	-	-	0.30 (1)	-	0.31 (1)	0.62 (2)	0.32 (1)	0.34 (1)	-	-	0.315	0.207	0.108
3.	MAUS-162	-	0.59 (2)	0.61 (2)	0.30 (1)	-	0.32 (1)	0.31 (1)	0.60 (2)	-	-	-	-	0.303	0.138	0.165
4.	MAUS-612	-	-	0.56 (2)	-	0.29 (1)	0.58 (2)	0.31 (1)	-	0.30 (1)	-	-	-	0.291	0.175	0.116
5.	JS-335	-	-	-	-	0.27 (1)	0.57 (2)	0.29 (1)	-	0.31 (1)		-	-	0.288	0.128	0.160
6.	JS-9305	-	-	-	-	0.31 (1)	0.33 (1)	-	-	0.31 (1)	0.32 (1)	-	-	0.317	0.144	0.173
7.	KDS-344	-	-	-	-	-	0.25 (1)	0.26 (1)	0.53 (2)	-	0.27 (1)	0.26 (1)	-	0.261	0.157	0.104
8.	KDS-726	-	0.76 (2)	0.31 (1)	-	0.32 (1)	0.74 (2)	-	0.31(1)	-	-	-	-	0.348	0.170	0.178
		Germination at 100% field capacity in Vertisols														
1.	MAUS-71	-	-	0.33 (1)	-	0.32 (1)	0.64 (2)	0.68 (2)	0.34 (1)	0.32 (1)	-	-	-	0.328	0.166	0.162
2.	MAUS-158	-	-	-	-	-	0.29 (1)	0.57 (2)	0.31 (1)	0.56 (2)	0.30 (1)	-	-	0.290	0.177	0.113
3.	MAUS-162	-	0.54 (2)	0.58 (2)	0.29 (1)	-	0.28 (1)	0.56 (2)	-	0.29 (1)	-	-	-	0.282	0.101	0.181
4.	MAUS-612	-	-	0.52 (2)	0.27 (1)	-	0.54 (2)	0.28 (1)	-	0.30 (1)	0.27 (1)	-	-	0.272	0.160	0.112
5.	JS-335	-	-	-	-	0.27 (1)	0.56 (2)	0.57 (2)	0.29 (1)	0.32 (1)	-	-	-	0.287	0.129	0.158
6.	JS-9305	-	-	-	-	0.62 (2)	0.31 (1)	-	0.64 (2)	-	0.32 (1)	0.30 (1)	-	0.313	0.145	0.168
7.	KDS-344	-	-	-	-	0.26 (1)	0.54 (2)	-	0.27 (1)	0.56 (2)	0.29 (1)	-	-	0.274	0.165	0.109
8.	KDS-726	-	0.62 (2)	0.31 (1)	-	0.32 (1)	0.92 (3)	-	0.33 (1)	-	-	-	-	0.312	0.129	0.183

From this study it was observed that the seed hydration value is important factor for seed germination and the effect of variety was also found significant with lowest seed hydration value. It was due to the variety having lowest seed hydration value indicates that this variety requires less moisture levels for seed germination and it was also suitable in low moisture regimes like rainfed areas. The varieties MAUS-158 and KDS-344 shows lowest seed hydration value i.e., 0.199 gram in both varieties and highest seed hydration value was recorded in varieties MAUS-162 and KDS-726 having values 0.174 gram and 0.173 gram respectively.

Table 12: Effect of different moisture levels on seed hydration value of soybean varieties in Vertisols soil

Treatments	Seed hydration value (g)
Moisture	
M1-50% FC	0.145
M2-75% FC	0.146
M3-100% FC	0.147
S.Em.	0.004
C.D. at 5%	0.012
Varieties	
V1-MAUS-71	0.160
V2-MAUS-158	0.119
V3-MAUS-162	0.174
V4-MAUS-612	0.121
V5-JS-335	0.138
V6-JS-9305	0.165
V7-KDS-344	0.119
V8-KDS-726	0.173
S.Em.	0.005
C.D. at 5%	0.015
Interaction	
S.Em.	0.0031
C.D. at 5%	0.0095

Data from Table 13 represents the interaction effect of different moisture levels on seed hydration value of soybean varieties in Vertisols soil and this data showed the significant result of the interaction. The lowest seed hydration was recorded in interaction V_5 (JS-335) x M_1 (50% field capacity) with value 0.104 gram and highest seed hydration value was recorded in interaction V_3 (MAIS-162) x M_3 (100% field capacity) with value 0.182 grams followed by V_8 (KDS-726) x M_3 (100% field capacity) with value 0.181 grams. The seed index of variety KDS-726 was highest and due to the highest seed index the seed hydration value of KDS-726 variety was also found highest.

The above results depicts that all varieties of soybean did not require the equal amount of water for germination of seeds and it showed that adaptation to germinate the seeds in hydric, xeric and mesic conditions as well. The same result of varietal differences was observed by Stiles (1948) [25] in the water absorbing capacity of different varieties of beans seeds. Borji *et al.*, (2007) [26] studied that low imbibition rate further leads to low seed hydration value which can also affect the germination of seed, composition of seed and seed coat microstructure influence the rate of imbibition.

Table 13: Interaction effect of different moisture levels on seed hydration value of soybean varieties in vertisols soil

Treatments	V1-MAUS-71	V2-MAUS-158	V3-MAUS-162	V4-MAUS-612	V5-JS-335	V6-JS-9305	V7-KDS-344	V8-KDS-726	Mean M (Moisture)
M1-50% FC	0.155	0.144	0.175	0.132	0.104	0.156	0.138	0.162	0.145
M2-75% FC	0.167	0.104	0.167	0.118	0.156	0.175	0.108	0.176	0.146
M3-100% FC	0.160	0.110	0.182	0.114	0.155	0.165	0.112	0.181	0.147
Mean V (Variety)	0.160	0.119	0.174	0.121	0.138	0.165	0.119	0.173	
Interaction	M	V	M X V						
S.Em.	0.004	0.005	0.0031						
C.D. at 5%	0.012	0.015	0.0095						

Table 14: Water absorption in different soil moisture at the time of germination by soybean varieties in Inceptisols soil

Sr. No.	Varieties	Time (hrs.)												Wet seed wt. (g/seed)	Dry seed wt. (g/seed)	Seed Hydration
		6-18	18-24	24-30	30-36	36-42	42-48	48-54	54-60	60-66	66-72	72-78	78-96			
		Germination at 50% field capacity in Inceptisols														
1.	MAUS-71	-	-	0.27 (1)	-	0.58 (2)	0.28 (1)	-	0.30 (1)	-	0.31 (1)	-	-	0.290	0.141	0.149
2.	MAUS-158	-	-	-	-	-	0.29 (1)	-	0.28 (1)	-	0.30 (1)	0.27 (1)	-	0.285	0.172	0.113
3.	MAUS-162	-	-	-	0.28 (1)	0.32 (1)	0.98 (4)	-	-	0.30 (1)	-	0.29 (1)	-	0.271	0.112	0.159
4.	MAUS-612	-	-	-	0.61 (2)	0.30 (1)	0.31 (1)	-	0.28 (1)	-	0.27 (1)	-	-	0.295	0.181	0.114
5.	JS-335	-	-	-	-	-	0.30 (1)	0.31 (1)	-	0.28 (1)	-	-	-	0.297	0.172	0.125
6.	JS-9305	-	-	-	-	0.32 (1)	-	0.31 (1)	-	0.31 (1)	-	-	-	0.313	0.162	0.151
7.	KDS-344	-	-	-	-	0.25 (1)	0.26 (1)	-	0.54 (2)	-	0.24 (1)	-	-	0.258	0.149	0.109
8.	KDS-726	-	-	0.32 (2)	-	0.31 (1)	0.63 (2)	-	0.30 (1)	-	-	-	-	0.260	0.100	0.160
		Germination at 75% field capacity in Inceptisols														
1.	MAUS-71	-	0.30 (1)	0.58 (2)	0.31 (1)	0.30 (1)	-	-	0.28 (1)	0.29 (1)	-	-	-	0.294	0.131	0.163
2.	MAUS-158	-	-	-	-	-	-	0.31 (1)	0.61 (2)	0.58 (2)	0.28 (1)	-	-	0.296	0.153	0.143
3.	MAUS-162	-	0.56 (2)	0.77 (3)	0.29 (1)	-	0.54 (2)	-	-	-	-	-	-	0.270	0.103	0.167
4.	MAUS-612	-	-	-	0.54 (2)	0.28 (1)	0.29 (1)	-	0.27 (1)	0.28 (1)	-	0.26 (1)	-	0.274	0.136	0.138
5.	JS-335	-	-	-	0.27 (1)	-	-	0.56 (2)	0.28 (1)	0.27 (1)	-	-	-	0.276	0.111	0.165
6.	JS-9305	-	-	-	-	0.31 (1)	0.29 (1)	-	0.30 (1)	-	0.28 (1)	-	-	0.295	0.127	0.168
7.	KDS-344	-	-	-	0.31 (1)	-	0.27 (1)	0.56 (2)	-	0.28 (1)	-	0.29 (1)	-	0.285	0.145	0.140
8.	KDS-726	-	0.62 (2)	-	0.96 (3)	-	0.32 (1)	-	0.31 (1)	-	-	-	-	0.315	0.143	0.172
		Germination at 100% field capacity in Inceptisols														
1.	MAUS-71	-	-	-	0.62 (2)	0.64 (2)	0.31 (1)	0.32 (1)	0.33 (1)	0.30 (1)	-	-	-	0.315	0.151	0.164
2.	MAUS-158	-	-	-	0.33 (1)	0.32 (1)	-	0.30 (1)	0.62 (2)	0.60 (2)	-	-	-	0.310	0.152	0.158
3.	MAUS-162	-	0.64 (2)	0.63 (2)	0.32 (1)	0.30 (1)	0.31 (1)	0.32 (1)	0.29 (1)	-	-	-	-	0.312	0.140	0.172
4.	MAUS-612	-	-	0.28 (1)	0.27 (1)	0.56 (2)	-	0.54 (2)	-	0.28 (1)	-	0.27 (1)	-	0.275	0.119	0.156
5.	JS-335	-	-	-	-	0.31 (1)	0.62 (2)	0.30 (1)	0.60 (2)	0.29 (1)	-	-	-	0.302	0.161	0.141
6.	JS-9305	-	-	-	-	0.32 (1)	0.33 (1)	0.31 (1)	0.64 (2)	-	0.31 (1)	-	0.29 (1)	0.314	0.149	0.165
7.	KDS-344	-	-	-	0.26 (1)	-	0.54 (2)	0.52 (2)	-	0.27 (1)	-	0.28 (1)	-	0.267	0.115	0.152
8.	KDS-726	-	0.72 (2)	0.32 (1)	-	0.74 (2)	0.30 (1)	-	0.31 (1)	-	-	-	-	0.341	0.167	0.174

Time of water absorption required for germination in soybean varieties at different moisture levels in Inceptisols soil

The data from Table 14 represented that time required for imbibition of water or seed hydration of germinated wet seeds in three different moisture levels i.e., 50%, 75% and 100% at different time interval in Inceptisols soil. The time required for water absorption vary according to different variety of seeds of soybean. Among all eight varieties of soybean, MAUS-162 and KDS-726 shows early seed hydration than other varieties. More seed hydration value for germination of seeds was reported in time interval of 36 to 48 hours at all three field capacities. After 78 hours, there were no seed hydration took place. Generally, seed hydration occurred in time interval 18 to 78 hours in Inceptisols soil.

Table 15: Effect of different moisture levels on seed hydration value of soybean varieties in Inceptisols soil

Treatments	Seed hydration value (g)
Moisture	
M1-50% FC	0.133
M2-75% FC	0.155
M3-100% FC	0.158
S.Em.	0.0014
C.D. at 5%	0.0041
Varieties	
V1-MAUS-71	0.156
V2-MAUS-158	0.137
V3-MAUS-162	0.165
V4-MAUS-612	0.135
V5-JS-335	0.140
V6-JS-9305	0.158
V7-KDS-344	0.134
V8-KDS-726	0.165
S.Em.	0.0035
C.D. at 5%	0.010
Interaction	
S.Em.	0.0031
C.D. at 5%	0.0091

3.10 Effect of different moisture levels on seed hydration value of soybean varieties in Inceptisols soil

The data presented in Table 15 represents the effect of different moisture levels on seed hydration value in soybean varieties at three different field capacities. The significant result was observed in Inceptisols soil with respect to water absorption or seed hydration value by seeds of soybean varieties. The highest seed hydration value was observed 100% field capacity i.e., 0.158 grams which was followed by 70% field capacity with value 0.155 grams. The lowest seed hydration value in M_1-50% with value 0.133 grams. From this result, the seed hydration value is an important factor for seed germination. The variety KDS-344 shows lowest seed hydration value with 0.134 grams followed by MAUS-612 and MAUS-158. Maximum seed hydration value was recorded in varieties MAUS-162 and KDS-726 having seed hydration value of 0.165 grams in both varieties.

The data from Table 16 revealed the interaction effect of different moisture levels on seed hydration value of soybean varieties in Inceptisols soil and this data showed the significant result of the interaction. The lowest seed hydration was recorded in interaction V_7 (KDS-344) x M_1 (50% field capacity) with value 0.110 gram. The highest seed hydration value was recorded in interaction V_8 (KDS-726) x M_3 (100% field capacity) with value 0.172 grams.

In Inceptisols soil, the highest germination percentage was observed in M_3-100% moisture level at field capacity. Hence, the interaction effect of moisture level and different soybean varieties was also related with the field capacity i.e., 100%. The seed index of variety KDS-726 was highest and thus seed hydration value of this variety is also highest. From this result it was concluded that the germination of seed and seed hydration value indicates that Inceptisols soil showed better germination percentage and more seed hydration in soybean varieties. This is might be due to better soil-seed contact area which shows more water absorption by seeds. Ren and Tao (2003) [28] observed from their study that imbibition rates were different in different species of *Calligonum* and also the function of dry mass of seeds.

Table 16: Interaction effect of different moisture levels on seed hydration value of soybean varieties in Inceptisols soil

Treatments	V1-MAUS-71	V2-MAUS-158	V3-MAUS-162	V4-MAUS-612	V5-JS-335	V6-JS-9305	V7-KDS-344	V8-KDS-726	Mean M (Moisture)
M1-50% FC	0.147	0.111	0.158	0.112	0.122	0.149	0.110	0.158	0.133
M2-75% FC	0.161	0.144	0.168	0.136	0.162	0.164	0.142	0.167	0.155
M3-100% FC	0.160	0.157	0.169	0.158	0.137	0.162	0.150	0.172	0.158
Mean V (Variety)	0.156	0.137	0.165	0.135	0.140	0.158	0.134	0.165	
Interaction	M	V	M X V						
S.Em.	0.0014	0.0035	0.0031						
C.D. at 5%	0.0041	0.010	0.0091						

3.11 Time of water absorption required for germination in soybean varieties at different moisture levels in Entisols soil

The data from Table 17 represented that time required for water absorption or seed hydration of germinated wet seeds in three different moisture levels i.e., 50%, 75% and 100% at different time interval in Entisols soil. The time required for water absorption vary according to different variety of seeds of soybean. Among all eight varieties of soybean, MAUS-612 and JS-335 shows early seed hydration with more seed hydration values than other varieties. More seed hydration value for germination of seeds was reported in time interval of 42 to 54 hours at all three field capacities. Generally, seed hydration occurred in time interval 18 to 78 hours in Entisols soil. After 78 hours, there were very less seed hydration took place. Effect of different moisture levels on seed hydration according to varieties otherwise there was not relative effect of moisture levels.

Table 17: Water absorption in different soil moisture at the time of germination by soybean varieties in Entisols soil

Sr. No.	Varieties	Time (hrs.)												Wet seed wt. (g/seed)	Dry seed wt. (g/seed)	Seed Hydration
		6-18	18-24	24-30	30-36	36-42	42-48	48-54	54-60	60-66	66-72	72-78	78-96			
		Germination at 50% field capacity in Entisols														
1.	MAUS-71	-	-	-	-	0.30 (1)	0.32 (1)	0.31(1)	-	0.32 (1)	-	0.30 (1)	-	0.310	0.125	0.185
2.	MAUS-158	-	-	-	-	-	0.28 (1)	0.30 (1)	0.29 (1)	0.28 (1)	-	-	-	0.287	0.169	0.118
3.	MAUS-162	-	-	-	-	0.28 (1)	0.56 (2)	-	0.54 (2)	-	0.27 (1)	-	-	0.275	0.128	0.147
4.	MAUS-612	-	-	-	-	0.30 (1)	0.28 (1)	-	0.27 (1)	-	0.28 (1)	0.26 (1)	-	0.278	0.163	0.115
5.	JS-335	-	-	-	-	-	0.29 (1)	0.30 (1)	-	-	0.28 (1)	-	-	0.290	0.166	0.124
6.	JS-9305	-	-	-	-	-	0.32 (1)	-	0.31 (1)	-	-	-	-	0.315	0.152	0.163
7.	KDS-344	-	-	-	-	0.30 (1)	-	0.29 (1)	-	0.28 (1)	0.27 (1)	-	-	0.285	0.173	0.112
8.	KDS-726	-	-	-	0.32 (1)	-	0.64 (2)	0.30 (1)	-	0.31 (1)	-	-	-	0.314	0.150	0.164
		Germination at 75% field capacity in Entisols														
1.	MAUS-71	-	-	-	0.62 (2)	0.31 (1)	0.32 (1)	-	0.30 (1)	0.31 (1)	0.32 (1)	-	-	0.311	0.143	0.168
2.	MAUS-158	-	-	-	-	-	0.64 (2)	0.31 (1)	-	0.32 (1)	-	-	0.58 (2)	0.308	0.159	0.149
3.	MAUS-162	-	0.28 (1)	0.30 (1)	0.61 (2)	0.29 (1)	-	-	0.30 (1)	-	-	0.28 (1)	-	0.294	0.141	0.153
4.	MAUS-612	-	-	-	0.29 (1)	-	0.58 (2)	0.28 (1)	-	0.30 (1)	0.28 (1)	-	-	0.288	0.143	0.145
5.	JS-335	-	-	-	-	-	0.32 (1)	0.62 (2)	0.31 (1)	0.30 (1)	-	-	-	0.310	0.159	0.151
6.	JS-9305	-	-	-	-	-	0.31 (1)	0.32 (1)	-	0.31 (1)	-	0.29 (1)	-	0.307	0.137	0.170
7.	KDS-344	-	-	-	-	-	0.31 (1)	0.64 (2)	-	0.30 (1)	0.29 (1)	-	-	0.308	0.166	0.142
8.	KDS-726	-	-	-	0.64 (2)	0.32 (1)	0.62 (2)	-	0.31 (1)	-	-	-	-	0.315	0.143	0.172
		Germination at 100% field capacity in Entisols														
1.	MAUS-71	-	0.33 (1)	0.92 (3)	-	0.32 (1)	0.30 (1)	0.31 (1)	0.29 (1)	-	0.32 (1)	-	-	0.310	0.127	0.183
2.	MAUS-158	-	-	-	-	-	0.64 (2)	0.32 (1)	0.62 (2)	0.31 (1)	0.30 (1)	-	-	0.313	0.160	0.153
3.	MAUS-162	-	-	0.58 (2)	-	0.29 (1)	0.31 (1)	0.62 (2)	0.31 (1)	0.32 (1)	0.28 (1)	-	-	0.301	0.132	0.169
4.	MAUS-612	-	-	-	0.57 (2)	-	0.29 (1)	0.30 (1)	0.61 (2)	0.28 (1)	-	0.27 (1)	-	0.290	0.140	0.150
5.	JS-335	-	-	-	-	-	0.58 (2)	0.28 (1)	0.54 (2)	0.29 (1)	0.27 (1)	-	-	0.280	0.122	0.158
6.	JS-9305	-	-	-	-	-	0.32 (1)	0.62 (2)	0.30 (1)	0.33 (1)	0.31 (1)	-	0.30 (1)	0.311	0.142	0.169
7.	KDS-344	-	-	-	-	0.28 (1)	0.29 (1)	0.31 (1)	-	0.62 (2)	-	0.28 (1)	0.29 (1)	0.295	0.148	0.147
8.	KDS-726	-	-	0.64 (2)	0.34 (1)	-	0.62 (2)	0.31 (1)	0.30 (1)	0.32 (1)	-	-	-	0.316	0.131	0.185

Table 18: Effect of different moisture levels on seed hydration value of soybean varieties in Entisols soil

Treatments	Seed hydration value (g)
Moisture	
M1-50% FC	0.139
M2-75% FC	0.155
M3-100% FC	0.164
S.Em.	0.0037
C.D. at 5%	0.011
Varieties	
V1-MAUS-71	0.176
V2-MAUS-158	0.138
V3-MAUS-162	0.153
V4-MAUS-612	0.141
V5-JS-335	0.142
V6-JS-9305	0.167
V7-KDS-344	0.134
V8-KDS-726	0.172
S.Em.	0.0085
C.D. at 5%	0.025
Interaction	
S.Em.	0.011
C.D. at 5%	0.031

3.12 Effect of different moisture levels on seed hydration value of soybean varieties in Entisols soil

The data presented in Table 18 showed the effect of different moisture levels on seed hydration value in soybean varieties at three different field capacities. The significant result was observed in Entisols soil with respect to water absorption or seed hydration value by seeds of soybean varieties. The highest seed hydration value was observed at 100% field capacity i.e., 0.164 grams. The seed hydration value in M_1-50% and M_2-75% field capacities was 0.139 grams and 0.155 grams respectively. From this, minimum seed hydration value was observed in M_1-50% field capacity. This shows that seed hydration value is an important factor for seed germination. The variety KDS-344 shows lowest seed hydration value i.e., 0.134 grams followed by MAUS-158 with value 0.138 and highest seed hydration value was recorded in variety MAUS-71 with seed hydration value 0.176 grams followed by KDS-726 having seed hydration value of 0.172 grams.

The data from Table 19 revealed the interaction effect of different moisture levels on seed hydration value of soybean varieties in Entisols soil and this data showed the significant result of this interaction. The lowest seed hydration was recorded in interaction V_7 (KDS-344) x M_1 (50% field capacity) with value 0.114 gram. The highest seed hydration value was recorded in interaction V_8 (KDS-726) x M_3 (100% field capacity) with value 0.182 grams followed by V_1 (MAUS-71) x M_3 (100% field capacity) with seed hydration value 0.180 grams. The seed index of variety KDS-726 was highest and thus seed hydration value of this

variety is also highest. Al-Karaki (1998) [27] found that rate of water uptake was very much affected by size of seed at the time of sowing till germination. He observed that large seeds showed higher rate of water uptake than smaller seeds. From this result, the germination of seed and seed hydration value indicates that Entisols soil showed better germination percentage and more seed hydration in soybean varieties.

Table 19: Interaction effect of different moisture levels on seed hydration value of soybean varieties in Entisols soil

Treatments	V1-MAUS-71	V2-MAUS-158	V3-MAUS-162	V4-MAUS-612	V5-JS-335	V6-JS-9305	V7-KDS-344	V8-KDS-726	Mean M (Moisture)
M1-50% FC	0.182	0.117	0.145	0.114	0.122	0.160	0.114	0.161	0.139
M2-75% FC	0.165	0.147	0.151	0.147	0.149	0.168	0.143	0.173	0.155
M3-100% FC	0.180	0.150	0.164	0.162	0.155	0.172	0.145	0.182	0.164
Mean V (Variety)	0.176	0.138	0.153	0.141	0.142	0.167	0.134	0.172	
Interaction	M	V	M X V						
S.Em.	0.0037	0.0085	0.011						
C.D. at 5%	0.011	0.025	0.031						

4. Conclusion

Moisture levels 100% and 75% field capacities showed early and better germination than 50% field capacity for all soybean varieties. Among eight different soybean varieties, maximum germination percentage was recorded in MAUS-162 followed by MAUS-71 and minimum germination percentage was clearly noted in JS-9305 soybean variety. The main three soil types *viz*. Vertisols, Inceptisols and Entisols soils, Vertisols and Inceptisols indicated early emergence and better germination in different soybean varieties. The topmost seed germination of soybean varieties MAUS-162 and MAUS-71 was found to be greater than 80% at 75% field capacity of soil moisture in very deep, moderately deep and shallow soils. The highest seed hydration value was recorded in MAUS-162 followed by KDS-726 in all three types of soils but best result was claimed in Vertisols soil. The lowest seed hydration value was reported in MAUS-158 and KDS-344 in all three types of soils. The earliest germination was recorded in MAUS-162 in all three types of soil and it performed well in terms of germination at 75% field capacity. So, from this innovative study it can be concluded that, the soybean varieties MAUS-162 and MAUS-71 were selected for early and higher germination under low rainfall i.e., 75% field capacity soil moisture and other varieties like JS-9305 and MAUS-158 to be sown at 100% field capacity soil moisture in soils of Marathwada region.

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