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EVALUATION OF SOYA-BEAN (GLYCINE MAX. L.) MERRILL) CULTIVARS FOR ADAPTABILITY AND YIELD PERFORMANCE IN THE LOWLANDS DISTRICTS OF LESOTHO.

By

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Abstract

Soya-bean is grown in small area by small holder farmers in the lowland districts of Lesotho without evaluating for suitability of each cultivar to a particular area, thus leading to low productivity. The study was therefore conducted to (i) evaluate six soya-bean cultivars for adaptation and high yield performance in five districts in the lowlands of Lesotho, namely; Botha-Bothe, Leribe, Mafeteng, Mohales'hoek and Quthing. Randomized Complete Block Design was applied to lay-out the plots with six treatments and replications. The dimensions for main plot and sub-plots were 33m length x 12m width and 6m length x 3m width, respectively. Yield data were collected after harvesting, after which it was captured and analyzed using Genstat Version 20. The results revealed that Mohales'hoek district outperformed all the other four districts in yield performance followed by Mafeteng, while Botha-Bothe was the lowest. Soya-bean cultivars DM6.8iRR, DM5351RSF and DM5953RSF out-performed the other five cultivars evaluated with. The interactions that produced highest yield were in Mohales'hoek planted with DM5351RSF (618.77g/plot), followed by DM68R09 with 615.83g/plot and DM5353 RSF (564.17g/plot), all in Mohales'hoek.

Keywords- : *Soya-bean, yield performance, Lesotho, multi-location trial, Analysis of variance*

Introduction to Nano-Bio Interfaces

Soya-bean (*Glycine max. L.* Merril) is a leguminous crop originating from China and domesticated from wild annual soya-bean (Glycine soja, sieb. and Zucc) in the Eastern half of South China (Sedivy, et al. 2016). Wild soy-bean is an annual weedy-form climber, whose pods contain black seeds that shatter at maturity. The plant grows wild in China and adjacent regions of Russia, Korea, Taiwan and Japan , and they are diverse in morphological feature and genomes (Hymowitz, 1970). Domesticated soya-bean was disseminated from China to far East of Asia, after which it was carried to Europe and then United States (Liu, et al., 2020). Nowadays, soy-bean is a world crop cultivated widely in Brazil (153 million metric tons), United States (113.27 million mt), Argentina (48.21million mt), China (20.84million mt), India (11.88 million mt), Paraguay (11million mt) and many other places (Ekanem, 2024; Volkova & Smolyaninova, 2024). Brazil is the major producer in soy-bean production world-wide.

The production and productivity of soya-bean are highly dependent on many growth factors differing in their impetuses (Shim, 2015). The factors are basically grouped into two categories, of which one is environment and the other genetic. The environmental factors are constituted by soil type and fertility level, temperature, solar radiation, precipitation, relative humidity, pests and diseases (Sobko, et al. 2020). All the environmental factors combined in varying proportions define the characteristics of a particular locality which may be suitable for certain soya-bean cultivars and unsuitable for others (Szostak, et al. 2020). Genetic factors refer to genetic constitution of particular cultivars which confer traits responsible for yield, quality and other traits (Kipshakbayeva, et al., 2024; Stephen, 2012). There is a great variation among the cultivars in each trait which facilitates selection in plant breeding programmes, without variation there would be no improvement in soya-bean crop (Li, et al., 2024). The traits of economic importance are mostly manipulated by the plant geneticists, agronomists and breeders alike in identifying, producing and breeding soya-bean cultivars (Singer, et al.2023). Among the traits of soya-bean most preferred and manipulated are yield potential, protein and oil content, phenological, diseases and pest resistance, and adaptation to different environmental conditions (Karges, et al., 2022; Dukariya, et al. 2020; Akinlolu, et al. 2019).

The traits of a soya-bean cultivar are influenced by the environment in which they grow resulting in it being fully

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expressed, modified and suppressed under conducive, unfavourable and harsh conditions, respectively (Sobko, et al. 2020; Win, et al, 2018). Some cultivars may perform consistently across all the environments, while others perform very well in some environments and poor in others, thus they are environment (locality) specific (Gurmu, et al., 2010). It is therefore imperative to evaluate new soya-bean cultivars in different environments to determine where they perform best, thereby matching cultivars to suitable localities (Oluwaseyi, et al. 2021).

In Lesotho, no multi-location trials have been conducted to evaluate soya-bean cultivars introduced to the country from South Africa (neighbouring country) annually by the farmers. The cultivars are grown by farmers in different parts of the country, in particular Quthing situated in the southern part of Lesotho (UNNutrition, 2022; Plenty Lesotho, 1979). Besides, the government of Lesotho is selling one cultivar of soya-bean across the country disregarding their suitability for localities. But it well documented that Lesotho has four agro-ecological zones which differ greatly in environmental conditions necessitating multi-location trials (Moeletsi & Walker, 2013). Farmers have a tendency of mixing cultivar thinking that they are

MATERIALS AND METHODS

Study area

The study was conducted in five low-land districts of Lesotho stretching from North East to South West of country, namely; Butha-Buthe, Leribe, Mafeteng, Mohale'shoek and Quthing. Each of these districts has distinct environmental conditions that differentiate them such as altitude, edaphic factors, climatic conditions, length of growing season, agronomic practices and general management of individual farmers.

Experimental design

Randomized Complete Block Design was applied to lay-out the plots with six treatments and replications. The dimensions for main plot and sub-plots were 33m length x 12m width and 6m length x 3m width, respectively. Each plot had four rows with inter-row spacing and intra-row-spacing of 0.9m x 0.20m, respectively.

Agronomic practices

Seed-bed was prepared using tractor mounted plough, after which disk harrow was used to break the clots and level the seed-bed. Compound fertilizer [2:3:2 (22) +2%Zn] was broadcast over the land at the rate of 250 kg ha-1 and raked in. Twelve plots were demarcated according to trial plan and the lines were drawn for placing seeds of different cultivars. Seeds were then sown on the drawn lines. Irrigation water was applied to give a good kick-start, after which it was left as a rain-fed crop. Weeding was performed thrice when the weeds were observed. No pests were observed throughout the growing season.

Data collection and analysis

Yield data were collected after harvesting. Data collected were captured in the Microsoft excel, after which it was analysed using Genstat 17 (Payne, et al., 2017). Least significant difference was employed to established the differences among the yields of different soya-bean cultivars.

RESULTS AND DISCUSSION

Localities

Analysis of variance revealed a highly significant ($P<0.01$) difference among 5 localities in terms of yield performance (Table 1). Mohales'hoek obtained the highest yield of 499.52g/plot, followed by Mafeteng with 452.44g/plot. The locality with the lowest yield was Botha-Bothe achieving 176.35g/plot, followed by Mahobong, (Leribe) with 212.49g/plot (Table 2). The mean yield for 5 localities was 346.02g/plot (Table 2).

The environmental conditions that existed in Mohales'hoek favoured the production of soya-bean, followed by Mafeteng. Generally, soya-bean cultivars were highly adapted to the two districts, hence the yield was high. Conversely, the environmental conditions in Botha-Bothe and Leribe districts revealed a poor performance attributed to unfavourable environmental conditions. Environmental conditions were constituted by rainfall, temperature, altitude, length of day-light and edaphic factors which differed from one district to the other. Different proportions of the afore-mentioned factors when combined in a particular locality determined the cultivar or crop that can be grown successfully or fail dismally. Chipeta et al, (2017) conducted an experiment planting eight cultivars of cassava in four localities and observed a differing yield across the environments (localities). Similarly, Sobko, et al. 2020) observed varying yield performance of thirteen mung bean cultivars across three different research stations. This implied that environmental condition had a great influence on yield resulting in either low or high yield based on suitability of condition for particular cultivars. Several other studies resonated well with this findings (Musundire, et al., 2021; Chipeta, et al., 2017).

Table 1. Analysis of variance

Source of variation	Sum of squares	df	Mean squares	Fratio	Sign
Location	15008.70	4	3752.176	70.027	0.000
Cultivars	1929.211	5	385.842	7.201	0.000
Location x cultivar	3121.640	20	156.082	2.913	0.001
Error	3214.906	60	53.582		
Total	131033.9	90			

a. R Squared = 0.862 (Adjusted R Squared = 0.795)

Table 2. Means of different localities

Location	Mean	Std.	5% Confidence interval	
			Lower	Upper

		Error	boundary	boundary
Mahobong	212.49	1.725	177.98	247.00
Bothaboth e	176.35	1.725	141.84	210.86
Mafeteng	452.44	1.725	417.93	486.96
Mohalesho k	499.52	1.725	465.01	534.03
Quthing	389.31	1.725	354.80	423.82

Cultivars

Highly significant difference (P<0.01) was expressed among 6 cultivars of soya-bean planted across 5 localities (Table 1). Cultivar with the highest mean yield was DM6.8iRR with 389.68 g/plot, followed by DM5351RSF with 381.61g/plot and DM5953RSF with 381.05g/plot. Cultivars that yielded very low were LS6248R with 262.00g/plot, followed by DM5302RSF with 309.16g/plot (Table 3). The grand mean for all cultivars was 346,03 g/plot.

The difference in yield performance among six cultivars grown on the same locality was attributed to the genetic constitution of cultivars which dissimilar. Degree of similarity between DM6.8iRR and DM5351RSF was high, but not exactly the same. This meant that they share most of the genes that constituted them, with very few being different. Degree of similarity between DM5351RSF and DM5953RSF was infinitesimal implying that there are almost the same, thus one gene may have caused the difference (Isogenic line). LS6248R differed greatly from other cultivars being the lowest among all. This implied that genetic constitution of this cultivar had a high degree of dissimilarity when compared to the others, hence lowest in performance while there were all evaluated on same environment. Adewale *et al*. (2017) conducted a study on 30 African yam bean cultivars in four localities and observed different yield performance at each location tested (Shim, 2015) carried out an investigation on adaptation of different cultivars in specific sets of environments and obtained results consistent with the afore-mentioned.

0 **Table 3 Performance of cultivars across the localities**

Cultivar	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
DM68R09	352.65	1.890	314.84	390.45
DM5302 RSF	309.16	1.890	271.35	346.97
DM5953 RSF	381.05	1.890	343.24	418.85
DM5351 RSF	381.61	1.890	343.80	419.41
LS6248R	262.00	1.890	224.19	299.81
DM6.8iR R	389.68	1.890	351.87	427.49

Location x Cultivar interaction

There was a highly significant (P<0.01) difference expressed by interaction of location and soya-bean cultivars (Table 1). The interactions that produced highest yield were in Mohales'hoek planted with DM5351RSF (618.77g/plot), followed by Mohales'hoek planted with DM5353 RSF (564.17g/plot), then DM68R09 with 615.83g/plot. The interactions with lowest yield were obtained in Botha-Bothe planted DM5351 RSF (104.33g/plot), followed by Botha-Bothe grown DM68R09 (174.80g/plot) (Table 4).

The interaction of location x cultivar showed the response of a cultivar on a particular locality which may be positive or negative. Positive interaction showed a high yield performance and a high adaption of the cultivar to the environment, while negative expressed negative yield performance. One cultivar may be consistent across all the environment. The environmental conditions in Mohales'hoek where DM5353 RSF (564.17g/plot) and DM68R09 (615.83g/plot) were planted revealed a highly positive response of cultivar x environment interaction, thus conditions were favourable for growth and development. Conversely, Environmental conditions in Botha-Bothe where DM5351 RSF (104.33g/plot) and DM68R09 (174.80g/plot) were grown did not favour the growth of two cultivars or match their requirements for optimum growth. Several researchers obtained similar results where interaction of cultivars of different crops with environment responded positively to some environments and negatively to some (Siamabele & Moral, 2021; Adewale, *et al*. 2017; Chipeta, *et al*, (2017).

Table 4. Location x Cultivar

Cultivar	Location	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
DM68R09	Mahobong	190.00[a]	4.226	105.46	274.54
	BothaBothe	203.13a	4.226	118.60	287.67

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	Mafeteng	449.33b	4.226	364.80	533.87
	MohalesHoek	513.77b	4.226	429.23	598.30
	Quthing	407.00c	4.226	322.46	491.54
	Mahobong	191.93a	4.226	107.40	276.47
DM5302RSF	BothaBothe	174.80d	4.226	90.26	259.34
	Mafeteng	352.00e	4.226	267.46	436.54
	MohalesHoek	491.27b	4.226	406.73	575.80
	Quthing	335.80e	4.226	251.26	420.34
	Mahobong	238.67a	4.226	154.13	323.20
DM5953RSF	BothaBothe	224.53a	4.226	140.00	309.07
	Mafeteng	488.33b	4.226	403.80	572.87
	MohalesHoek	564.17b	4.226	479.63	648.70
	Quthing	389.53c	4.226	305.00	474.07
	Mahobong	222.33a	4.226	137.80	306.87
DM5351RSF	BothaBothe	224.40a	4.226	139.86	308.94
	Mafeteng	471.67b	4.226	387.13	556.20
	MohalesHoek	**618.77f**	4.226	534.23	703.30
	Quthing	370.87c	4.226	286.33	455.40
	Mahobong	191.00d	4.226	106.46	275.54
LS6248R	BothaBothe	104.33g	4.226	10.80	188.87
	Mafeteng	470.00b	4.226	385.46	554.54
	MohalesHoek	193.33d	4.226	108.80	277.87
	Quthing	351.33e	4.226	266.80	435.87
	Mahobong	241.00a	4.226	156.46	325.54
DM6.8iRR	BothaBothe	126.90g	4.226	42.36	211.44
	Mafeteng	483.33b	4.226	398.80	567.87
	MohalesHoek	**615.83f**	4.226	531.30	700.37
	Quthing	481.33b	4.226	396.80	565.87

CONCLUSION

Mohales'hoek district outperformed all the other four districts in yield performance followed by Mafeteng, while Botha-Bothe was the lowest. Soya-bean cultivars DM6.8iRR, DM5351RSF and DM5953RSF out-performed the other five cultivars evaluated with. The interactions that produced highest yield were in Mohales'hoek planted with DM5351RSF (618.77g/plot), followed by DM68R09 with 615.83g/plot and DM5353 RSF (564.17g/plot), all in Mohales'hoek.

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