ISSN: 2754-477X

Journal of Food Technology & Nutrition Sciences

SCIENTIFIC Research and Community

Research Article

Open Access

Variation in Oil Concentration and Agronomic Performances of Soybean Accessions at Chitwan, Nepal

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ABSTRACT

A field experiment was conducted at the agronomy block of National Cattle Research Program, Rampur, Chitwan, Nepal during the soybean growing season of fiscal year 2015. The objective of this study was to analyze oil concentration of soybean seed and also evaluate the yield performance and its correlation to yield components. Layout of field was carried out in Randomized Complete Block Design (RCBD) within three replications and comprised of 15 accessions. Laboratory analysis for oil concentration was done in the Department of Food Technology and Quality Control, Kathmandu by Soxhlet apparatus. There was significant variation in oil concentration found among the test accessions. The highest average oil concentration was found in TGX1990- 110FN (17.95%) followed by TGX1989-68FN (17.41%) and TGX1990-106FN (17.31%) while the highest yield was produced by IITA accession TGX1990-52F (4.30t/ha) followed by TGX1989-48FN (3.87t/ha) and TGX1989-45F (3.74t/ha). Correlation between the different yield attributing traits like days to 50% flowering, days to pod setting, days to maturity, plant height, seeds per ten pods, nodes per plant, number of branches and hundred seed weight with the yield was observed. The result showed the significant positive correlation towards the yield. Based on the above mentioned traits and the ranges of oil concentration can be given prime importance to enhance the breeding programs.

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Received: November 16, 2021; **Accepted:** November 23, 2021; **Published:** December 16, 2021

Keywords: Oil, Soybean, Yield, Morphological Traits

Introduction

Soybean (Glycine max, 2n=2x=40) is an important annual herb of leguminosae family and it is mainly grown for oil and protein. Primarily, soybean is an industrial crop and is grown for oil and protein and mostly it is grown in different 93 countries around the globe [1]. It contains about 37-42% good quality protein, 6% ash, 29% carbohydrate and 17-24% oil containing 85% unsaturated fatty acid with two essential fatty acids; linoleic and linolenic acid. These fatty acids are not synthesized in the human body so it is highly preferable and desirable in our human diet [2].

Soybean is considered as the third most important food legume grown in Nepal which is mostly grown as intercrop with maize or leeve paddy in bund sharing about 7% of the total legumes area In the mid hills of Nepal, mainly roasted soybean with maize is popular breakfast and roasted split soybean with garlic, green chili and beaten rice is the important dish during fun time and is the best source for human diet. In Nepal, soybean is mainly consumed as tiffin, snack and green pods are used as vegetables [4]. In the different markets in different parts of world, a huge variety of soybean made products like margarine, tofu, or soy cheese, soymilk, soy deserts, candies; pastry, cookies, cakes etc. are available [5]. In Asian countries soymilk is a popular beverage and its consumption has also an increasing rate of 21% per year in The United States too [6].

Originally, soybean was only used as forage crops and then they were grown mainly for the seeds and were used for fresh, dried and fermented food products. But now soybean is used for food, livestock feed, industrial processes, bio-fuel, and in pharmaceuticals [7]. In the present context, soybean has been the most economical and valuable agricultural commodity because of its multiple uses as food for human, feed and industrial purposes. It is known for its uniqueness as it contains highest protein among cereals and second highest oil content among all food legumes. Soybean is also the good source of components like isoflavones, lecithin, saponins, oligosaccharides and phytosterols and most of them act as anti-cancer agents and antioxidants Soybean is the leading oil which is being consumed in the world and it is also consumed in the different forms which include salad and cooking oil, margarine, shortening and mayonnaise. It is the most preferred oil for healthier life as compared to the other unsaturated oils. It is an excellent source of fatty acids, calories and is the precursors of Omega-3, Omega-6 and Vitamin E and at a lower price [9].

Nepalese food and feed industries expensed a huge amount of money to import the soybean crude oil from different countries. In 2014 alone, Nepal imported soybean crude oil of about Rupees 12 arab, 48 crore 32 lakh from India, Argentina, Brazil and Paraguay [28]. Since our country is being imported a huge amount of soybean and its crude materials, on this circumstances; soybean researchers should provide the option for substituting the imports hence it is quite essential task to identify the high yielding accession along with the high oil concentration soybean for the industries. To address the demand of niche market of soybean and soybean based products, it is essential to develop the soybean accessions suitable more for food as well as oil content rich cultivars [9].

The Objectives of the Research Are Given Below

- To find out the high oil concentration of soybean accessions.
- To evaluate and characterize the soybean's yield and yield attributing traits.
- To analyze the correlation among the important traits.

Materials and Methods

A total of fifteen soybean accession were received from the National Grain Legumes Research Programme, Khajura, Banke, Nepal which had selected earlier from the International Soybean Nurseries (IITA Set) (Table 1). The whole field research was conducted at the field of National Cattle Research Program, Rampur, Chitwan, Nepal, during the main growing season from July to November, 2015. The precise latitude, longitude and altitude of Rampur is 270 39′ 0.45″ North, 840 21′ 9.1″ East and 228 masl, respectively. The site is situated approximately 8 km South-West from Bharatpur, Chitwan, Nepal and geographically it falls in the inner Terai region of Central Development Region of Nepal.

The design of the experimental plot was laid out in Randomized Complete Block Design (RCBD) and the total treatments were fifteen with three replications. Parameters like seed emergence, date of flowering, date of pod setting were recorded after 50% of the respective observation was observed. The appearance of brown or grey (according to variety) pod setting and defoliated leaves are an indication to physiological maturity. 80-90% of the pod maturity was taken as harvesting date. Yield attributing traits like grain yield, plant height, pods per plant, number of branches per plant, test weight were also recorded in the data sheet.

Statistical Analysis

Different data sheet of yield attributing traits as mentioned above were collected and after harvesting, the seeds of different genotypes were collected from all the plots and brought to laboratory for oil content analysis. Data entry and processing was carried out using Microsoft Office Excel 2007 software and mean and standard deviations for all quantitative traits were computed. Analysis of variance and multiple mean comparisons were performed using the R software (3.3.1) to identify significant treatment effects and interactions. Differences among mean values were determined using Least Significant Differences.

Table 1: List of Different Soybean Genotypes Used for This Experiment

S.N.	Genotype name	Introduction Year	Origin	Source
1	TGX1990 – 95F	2016	IITA	NGLRP
2	TGX1485 – 1D	2016	IITA	NGLRP
3	TGX1989 – 48FN	2016	IITA	NGLRP
4	TGX1990 – 40F	2016	IITA	NGLRP
5	PUJA (Check)	2004	India	NGLRP
6	TGX1990 – 52F	2016	IITA	NGLRP
7	TGX1990 – 110FN	2016	IITA	NGLRP
8	TGX1989 – 45F	2016	IITA	NGLRP
9	TGX1993 – 4FN	2016	IITA	NGLRP
10	TGX1990 – 106FN	2016	IITA	NGLRP
11	TGX1989 – 68FN	2016	IITA	NGLRP
12	TGX1990 – 80F	2016	IITA	NGLRP
13	TGX1990 – 114FN	2016	IITA	NGLRP
14	TGX1987 – 62F	2016	IITA	NGLRP
15	TGX1987 – 10F	2016	IITA	NGLRP

Method for Oil Extraction

Two hundred and fifty gram of each seed sample was taken for oil extraction. 250g of sample was grinded into fine particles with mortar and pestle. Sample was quartered and 5-8g of powdered sample was obtained and crude oil was extracted with n-hexane in a Soxhlet apparatus for 12 hrs. The apparatus extracts crude fat from the sample by recycling hot solvent, usually petroleum ether. The apparatus consists of 3 easy-to-fit parts, namely, the extraction tube (into which sample in a thimble is kept immersed in solvent for fat extraction), the receiving flask (which receives through a siphon system the solvent + extracted fat from the extraction tube and vaporizes the solvent selectively for recycling), and the condenser (which condenses the vaporized solvent onto the sample placed in the extraction tube). The recycling is done for a certain number of times (until the extraction is complete) and the fat recovered by evaporating away the solvent. After drying the solution with anhydrous sodium sulphate, solvent was removed by vacuum distillation at 30°C. Oil percentages were determined by weight difference. Oil content was calculated at Department of Food Technology and Quality Control, Kathmandu, Nepal.

Results and Discussions

Results

Mean Performance and Analysis of Variation

Nodule Number

Highly significant (P≤.01) differences were recorded among 15 accessions for this trait (Table 2). The average nodule number for the experimented accessions was 63 with the range of 44~96. TGX1989-68FN had the highest value for nodule number (96) while Puja had the lowest (44).

Days To 50% Flowering

There were highly significant differences among the 15 accessions for the days to 50% flowering. The average days to 50% flowering was 52 and its range was 42~59 (Table 2). TGX1987-62F had significantly highest value for days to 50% flowering (59) while Puja had significantly lowest value for the days to 50% flowering (42).

Days To 50% Pod Setting

Analysis of variance (ANOVA) revealed highly significant difference among 15 accessions for this trait (Table 2). The average day to 50% pod setting was 73. TGX1990-52F had the highest value for this trait (82) while TGX1990-80F had the lowest value for the days to 50% pod setting which was statistically at par with TGX1990- 110FN (67).

Days to Maturity

Highly significant differences were found among 15 accessions for this trait. The average days to maturity were 116 with the range of 101~128(Table 2). TGX1987-62F (128) which was statistically at par with TGX1990- 52F was significantly late maturing accession and the accession TGX1990-110FN (101) was early maturing type.

Plant Height (Cm)

There were highly significant differences among the 15 accession for the height of the plant. The average plant height was 52cm and its range was 43~65 as shown in the Table 2. The highest plant height was found on the genotype TGX1989-45F (65cm) which was statistically at par with TGX1485-1D (65cm) while the lowest plant height was found on Puja (43cm) variety.

Seeds per 10 Pods

Highly significant differences were found among the 15 accessions for the seeds per 10 pods. The average seed per 10 pods was 21(Table 2). The greatest number of seeds per 10 pods was of the accessionTGX1990-80F (23)

And in the same way the lowest seeds per 10 pods was of the Puja (20) variety which is statistically at par with TGX1990-40F (20), TGX1993-4FN (20), TGX1485-1D (20), TGX1989-68FN (20) and TGX1990-114FN (20).

Number of Nodes

There was highly significantdifference for the number of nodes among the 15 accessions used in the research. The average number of nodes was 13 (Table 2). The highest number of nodes was of the genotype TGX1987-10F (15) which was statistically at par with TGX1989-48FN (15) while the lowest number of nodes was of the genotype Puja (10) which was statistically at par with TGX1993-4FN (11).

Number of Branches

Highly significant difference was found for the number of branches among the 15 accessions of soybean. The mean value was 6 (Table 2). The highest number of branches was of the accessions TGX1990-52F (9) while the lowest number of the number of branches was of the accession TGX1993-4FN (4) which was statistically at par with Puja (4).

Seed Diameter (mm)

There was highly significant difference for the seed diameter among the 15 accessions of soybean. The mean seed diameter was 4.78mm (Table 2). The highest seed diameter was found in the seed of the accession TGX1990-52F (5.37mm) which was statistically at par with TGX1485 (5.12mm) while the lowest seed diameter is of the accession TGX1990-80F (4.31mm) which was statistically at par with TGX1990-114FN (4.32mm) and TGX1990-106FN (4.32mm).

Test Weight (gram)

Highly significant difference was found for the test weight among the 15 accessions of soybean used in the research. The mean test weight was 134.50g whose range was 122.00~153.67 (Table 5). The highest test weight was of the accession TGX1990-52F (153.67g) while the lowest test weight was of the accession TGX1990-110FN (122.00g).

Grain Yield (t/ha)

Highly significantly difference was found for the grain yield among the 15 accessions of the soybean. Based on the Table 5, the mean of the grain yield was 2.72t/ha and its range was from 1.43~4.30. The significantly highest yield was found in the accession TGX1990-52F (4.30t/ha) while the significantly lowest yield was observed in TGX1993-4FN (1.43t/ha). High variation was found in the grain yield in the accessions. Out of the 15 accessions, seven g accessions had higher yield than the average mean of the yield i.e. higher than 2.72t/ha. However, twelve accessions gave higher yield than the mostly growing released variety (Puja) in the locality.

Oil Concentration (%)

There was highly significant difference among the 15 accessions used in the research for the oil content. The average value of the oil concentration was 15.90% and the range was 13.30~17.95 (Table 5). Significantly highest oil concentration was of the accession TGX1990-80F (17.95%) which was statistically at par with TGX1990-110FN (17.43%) and TGX1989-68FN (17.41%) while the accessions with significantly lowest oil concentration was of the Puja (13.30%) variety.

Table 2: Agronomic Performances of the Soybean Genotypes

S.N	Genotype	NN	DF	DP	DM	PH (cm)	PP	SP	NoN	NB	SD (mm)	SW (g)	TW (g)	GY (t/ha)	Oil (%)
1	TGX1990-95F	60	51	71	111	54	76	22	14	6	5.08	13.70	137.00	2.19	14.52
2	TGX1485-1D	63	54	74	114	65	78	20	14	6	5.12	13.63	136.33	2.85	15.44
3	TGX1989-48FN	54	57	80	124	54	119	21	15	7	4.87	12.60	126.00	3.87	16.51
4	TGX1990-40F	63	53	72	113	50	81	20	14	5	4.46	13.73	137.33	3.34	16.42
5	TGX1990-110FN	63	51	67	101	50	71	20	12	5	4.41	12.20	122.00	1.83	17.43
6	TGX1990-52F	66	56	82	128	46	91	21	13	9	5.37	15.37	153.67	4.30	15.51
7	Puja	44	42	69	117	43	40	20	10	4	5.06	13.90	139.00	1.97	13.30
8	TGX1989-45F	56	52	74	115	65	100	22	13	8	5.08	14.10	141.00	3.74	15.69
9	TGX1993-4FN	48	50	69	115	48	80	20	11	4	5.07	13.80	138.00	1.43	14.28
10	TGX1990-106FN	51	50	71	111	59	92	21	14	6	4.32	13.47	134.67	3.19	17.32
11	TGX1989-68FN	96	53	72	111	45	69	20	13	5	4.67	12.30	123.00	2.49	17.41
12	TGX1990-80F	79	51	67	111	46	68	23	12	5	4.31	12.87	128.67	2.25	17.95
13	TGX1990-114FN	59	50	69	115	51	87	20	12	6	4.32	12.40	123.00	2.00	16.47
14	TGX1987-62F	73	59	81	128	49	82	22	13	6	4.96	14.20	142.00	2.87	14.70
15	TGX1987-10F	74	50	73	124	57	95	21	15	5	5.06	13.53	135.33	2.47	15.56
	Mean	63	52	73	116	52	81	21	13	6	4.78	13.45	134.50	2.72	15.90
	Range	44~96	42~57	67~82	101~128	43~65	40~119	20~23	10~15	4~9	4.31~5.37	12.20~15.37	122.0~153.67	1.43~4.30	13.30~17.95
	F-test (P- value)	0.0093**	<2e-16**	<2e-16**	<2e-16**	0.0003**	1.33e-07**	0.0003**	0.0005**	0.0003**	Ns	2.591e-7**	5.50e-09 *	1.532e-15**	1.532e-15**
	LSD0.05	23	0.98	1.21	1.70	8.93	16.27	1.14	2.01	1.77	0.28	0.80	7.97	0.31	0.81
	CV (%)	21.53	1.13	0.99	0.88	10.24	11.96	3.27	9.33	18	3.64	3.54	3.54	22	4.16

Note: NN=nodule number, DF= Days to 50% flowering, DP= Days to 50% pod setting, DM= Days to maturity, PH= Plant Height, PP= Pods per plant, SP=seeds per 10 pods, NoN= number of nodes, NB= Number of Branches, SD= Seed Diameter, SW=100 seed weight, TW=Test weight, GY= Grain Yield, Oil=Oil Concentration.

Correlation Coefficient Analysis

Correlation between the different yield traits and the yield was done as in Table 3. Yield is one of the most important selection criteria and it is influenced by different yield components that include days to flowering, plant height, number of pods and seeds per plant and weight of 100 seeds.

The correlation Table 3 shows that there was a positive and significantly association with yield and days to 50% flowering (r=0.5637, P≤.01). Similarly, based on the correlation, there was highly significant and positive association between the yields with the different traits; days to maturity, number of branches/plant, number of pods/plant and 100-seeds weight at 1% level of significance.

Days to 50% flowering was positively and significantly associated with number of branches per plant(r=0.4732, P≤.01) and number of pods per plant (r=0.5684, P≤.01). There was also positive but no significant correlation with 100 seed weight and also there was a highly significant correlation with the seed yield (r=0.5637, P≤.01) (Table 3).

Similarly, there was positive and significant correlation between days to maturity and number of branches per plant (r=0.3597, P≤.05) and number of pods per plant(r=0.3713, P≤.05) and likewise there was highly significant positive association of days to maturity with 100-seed weight (r=0.5139, P≤.01) and seed yield (r=0.5124, P≤.01) (Table 3).

Likewise, plant height had significantly positive association with number of pods per plant (r=0.4568, P≤.01) and positive but no significant association with seed yield (Table 3).

There was a positive and significant association with number of branches per plant with no of pods per plant(r=0.5314, P≤.01) and similarly positive association was observed with 100 seed weight(r=0.3181, P≤.05) and also with seed yield(r=0.6974, P≤.01).

Table 3: Pearson's Product-Moment Correlation between the Different Yield Traits and Seed Yield of Soybean

Characters	Days to 50% Flowering	Plant height (cm)	No. of Branches/ Plant	No. of pods/ Plant	100-seed Weight	Seed Yield (ton/ha)
Days to 50% Flowering	1	0.1105	0.4732**	0.5684**	0.1190	0.5637**
Days to Maturity		-0.0307	0.3597*	0.3713*	0.5139**	0.5124**
Plant height (cm)		1	0.2056	0.4568**	0.0071	0.2283
No. of Branches /plant			1	0.5314**	0.3181*	0.6974**
No. of pods/plant				1	0.0002	0.6221**
100-seed weight					1	0.4012**
Seed yield (ton/ha)						1

Note: ** and * indicates significant at 1% and 5% level of significance

Similarly highly significant correlation was observed between the number of pods per plant with the yield of the plant (r=0.6221, P≤.01) and similar association was also recorded between the 100 seed weight and the yield (r=0.4012, P≤.01) (Table 3).

Discussion

Mean Performances and Analysis of Variation

Agronomic traits

There were significantly differences among all the traits studied in the fifteen soybean genotypes. Mean squares from analysis of variance (Table 2) showed that the fifteen soybean genotypes were highly variable with respect to grain yield, number of nodules , plant height, days to flowering, days to maturity, number of nodes, seeds per 10 pods, number of branches, 100 seed weight and oil content. Similarly, [10]. also found highly significant differences in the genotypes observed for all the traits considered (days to 50% flowering, plant height, number of pods per plant, 100 seed weight and grain yield). Malik, Ashraf, [12]. found a large variation in several agronomic traits; pods per plant, branches per plant, 100 seed weight and grain yield and it also indicates a high level of diversity supporting our research.

Regarding the variability's observed in the research, the plant breeder have the ample scope for the variety improvement considering the superior traits [12]. Suggested that changes in variance and increased performance in the agronomic traits can be used to select superior lines from within already established soybean cultivars [13]. confirmed that different genotypes were highly variable with respect to grain yield, days to flowering, days to maturity, number of nodules, to confirm the observed variations stated above.

There was great variation of plant height at maturity. It is supported from this study of. These results also agree with earlier work done by [15,16]. Who observed significant differences among soybean cultivars for plant height. This variation also gives us the idea in developing the early maturing varieties.

There was also a significantly difference in the yield of the soybean genotypes [15]. supported the statement. The high yielding genotypes can be further employed in order to increase the production of the soybean which is a miracle crop being the crop of both protein and oil rich.

The variations observed in the soybean genotypes in different traits suggest that the soybean has wide genetic base and the breeders can utilize this for improving the yield traits. Variability in soybeans was used to improve agronomic performance traits such as yield, seed protein and oil content, and plant height, which enabled the selection of new germplasm [17].

Oil Concentration

There was highly significant difference (P≤.01) among the 15 genotypes used in the research for the oil concentration (Table 2). Oil concentration differs according to the genotype [18]. Also mentioned that oil concentration differs due to the maternal parent of the genotype. Genetic and environmental factors determine the oil concentration of soybeans [19,20]. Thus the difference in the oil concentration had occurred due to the several factors mainly the genotype and the environment.

Correlation among the Yield Traits and Yield

Yield was positively and significantly correlated with days to flowering, days to maturity, number of branches per plant, pods/ plant and 100 seed weight. In the same way, plant height was also positively but not significantly associated with yield. Positive and strong association of number of pods per plant, branches per plant and 100 seeds weight with the yield focuses the importance of these characters in determining the grain yield (Table 3). Several correlations were not significant, i.e., indicating that there was no linear relationship between those traits; however, Da-Cruz Pradella, Ienczak, [21]. Suggested that this does not necessarily mean that there was no association between the traits.

Grain yield is one of the most important selection criteria used by breeders. It is influenced by different yield components that include number of pods and seeds per plant, and weight of 100 seeds [22]. There was a positive and highly significant correlation of number of pods with number of branches and seed yield. Plant height had positive and highly significant with number of pods/ plant (Table 3). This is strongly supported by [23]. Rajanna, Viswanatha, [24] and [25]. Also reported similar findings for different traits in soybean.

This experiment also showed the positive correlation with plant height and seed yield but it was not significant. This is in accordance to the works done by as well as is also confirmed by Oz, Karasu, [26].

Days to 50% flowering were positively and significantly associated with number of branches per plant and number of pods per plant at 1% level of significance (Table 3) Ojo [3]. Support the positive correlation between the days to 50% flowering and number of pods. Similarly, both the correlations are confirmed by Rodrigues, Serafim, Nogueira, Hamawaki, de [27]. There was positive and significant correlation between days to maturity and number of branches per plant and number of pods per plant.

There was a positive and significant association with number of branches per plant with no of pods per plant and 100 seed weight and similarly with seed yield. This was in confirmation with the reports of [23].

Conclusions

Based on the laboratory analysis of oil concentration, soybean genotype TGX1990-80F had the highest oil concentration i.e. 17.95% followed by TGX1990-110FN, TGX1989-68FN (17.41%) and TGX1990-106FN (17.31%).

Similarly yield was found to be significantly positive correlated with days to flowering, days to maturity, number of branches per plant, pods per plant and 100 seed weight. Thus, the factors affecting the performance of yield can be considered in the breeding programs. Overall results showed that the highest yielding accession was TGX1990-52F (4.30t/ha) followed by TGX1989-48FN (3.87t/ha) and TGX1989-45F (3.74t/ha).

Based on the both traits; oil concentration and the yield performances, the accession, TGX1989-48FN was the best with 3.87t/ha yield and 16.50% oil concentration from the study. Further research needs to be carried out on these accessions which have wider adaptability. The study also showed that TGX1990-110FN as the earliest maturing accession but it had comparatively very low grain yield whereas the late maturing accession gave the highest yield.

The research revealed that highest yielding accession were TGX1990-52F, TGX1989-48FN and TGX1989- 45F whereas TGX1990-80F, TGX1990-110FN and TGX1989-68FN were the possible candidates for high oil concentration lines however for both qualities in terms of yield performances and oil concentration, accession TGX1989-48FN was found outstanding and have good information for the concern industries. Overall further breeding improvement works need to be carried out on this in order to develop the ideal genotype.

Acknowledgements

This research was supported under grant from National Agricultural Research and Development Fund (NARDF). We would also like to acknowledge National Grain Legume Research Program, Khajura, Banke for providing soybean accessions and National Cattle Research Program, Chitwan, Nepal for providing field for the research. We would like to thank Agriculture and Forestry University for providing the platform to conduct the research. We would also like to thank all the helping hands for their direct and indirect supports.

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