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Research Article

Evaluation of the growth and yield characteristics of various genotypes of the soybean [*Glycine max* (L.) Merr.]

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ABSTRACT

Eighteen genotypes of soybean were evaluated in coordinated varietal trial in 2018 and eight genotypes in pre-released varietal trial in 2019 at National Plant Breeding and Genetics Research Centre, Khumaltar, Lalitpur, Nepal. The experimental design was randomized complete block design (RCBD) with three replications. The results showed that the maximum yield was obtained from CN-60 (2858 kg/ha) followed by CM-9133 (2791 kg/ha) in 2018 and CM-9125 (2708 kg/ha) followed by G-1872 (2666 kg/ha) in 2019. Similarly, combined analysis of pre-released varietal trial showed that grain yield was maximum for the LS-22-16-16 (2737.5 kg/ha) followed by G-4508 (2718.5 kg/ha) in 2018 and 2019. Thus, LS-22-16-16 and G-4508 seeds can be delivered to farmers as a farmers acceptance test for the release of soybean variety, while CN-60 and CM-9133 can be promoted to pre-released varietal trial.

Keywords: Soybean, genotypes, mid hill, evaluation, yield.

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INTRODUCTION

Soybean (*Glycine max.* L. Merril) is an important legume crop forhill-based farmers in Nepal.It is mostly grown in themid-hillsat an altitude ranging from 3000-5000 feet from the mean sea level. Soybean seeds contain a high amount of protein (40-45 %), 20 % of oil-rich with vitamins B, C, and E, and minerals (Yofa *et al.*, 2021). Its seed is also used as green pods, soybean oil, roasted grain, green manure, animal feed, and industrial products (Thapa *et al.*, 2014; Shrestha *et al.*, 2011). This plant is used both as a legume and an oil seed crop. The agricultural, nutritional, and economic values of soybean are well recognized so it has huge importance in the Nepalese economy (Shrestha *et al.*, 2021). It is grown as a sole crop, with maize and finger millet as an intercrop and, at the bunds of rice fields (Thapa *et al.*, 2014). Though farmers grow soybean as a traditional crop, it is seldom grown as a pure crop (Sharma, 1994).

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Soybean was grown in about 23,030 ha area which produced 30, 648 metric ton with productivity of 1.33 ton per hectare in 2077/78. Similarly, it was grown in 26,775 ha of land producing 34,544 tons with a productivity of 1.29 t/ha in 2076/77. In the same way, soybean covered 25,179 ha area producing 31,567 tons with a productivity of 1.25 t/ha (MoALD, 2022). This trend shows that the area, production, and productivity of soybean crops in the country are raising which might be due to awareness of their nutritional and economic value among the farmers.

The major cause behind the low productivity of this crop might be poor crop management practices and a lack of high-yielding promising varieties (Manandhar, 2021). Other reasons are that this crop is grown as an intercrop and therefore does not receive much attention for its proper care and management. It is because there might be competition for nutrients between soybean and maize/millet during its growth and development (Shrestha *et al.*, 2021). Although this is an important crop commodity, its research has received relatively less attentionin Nepal as the primary focus is on assuring food supply for the growing population (Agronomy Division, 2011). There exists a huge yield gap between research potential yield and the national average yield which needs to be addressed. The objective of this experiment was to identify the high yielding soybean genotypes for mid hill of Nepal.

MATERIALS AND METHODS

The experimental site was research field of National Plant Breeding and Genetics Research Centre, Khumaltar, Lalitpur, Nepal. It is located at $85^0$02'E longitude, $27^0$04' N latitude and 1350 m altitude (NARC, 2018). Soil pH ranged from 6.5 to 7.0. Soil was well-drained. The soil in the experimental plot was silty clay loam. The temperature ranged from 13.8 °C to 24.4 °C with 1305.8 mm total rainfall and 147 rainy days.The details of meteorological data during the experiment is given in Table 1. The source of genotypes used in these experiments was from of National Plant Breeding and Genetics Research Centre, Khumaltar, Lalitpur, Nepal and Grain Legume Research Program (GLRP), Khajura, Banke, Nepal. The experiment was conducted in randomized complete block design (RCBD) with three replications. Total 18 genotypes were evaluated in the coordinated varietal trial (CVT) in 2018 and 8 genotypes in pre-released varietal trial (PRVT) in 2019. The plot size was taken as 4 m × 1 m where the row-to-row distance was maintained as 50 cm and the plant-to-plant distance as 5 cm. The standard agronomic package of practices was followed with recommended fertilizer dose (N:P_2O_5:K_2O @ 20:40:20 kg/ha). For weeding purposes, pendimethalin was sprayed as a pre-emergence weedicide followed by one-hand weeding and earthing up after 50 days of sowing. Major soybean traits were recorded such as early stand, final stand, days to flowering, and days to maturity, plant height, no. of pods per plant, number of utilized pods per plant, number of branches per plant, and grain yield etc. Early stand means the initial germination of soybean plants in the field whereas final stand means the number of total soybean plants counted after grain maturity. Early stand and final stand were taken in number. Days to flowering and maturity were also taken in number of days where flowering days were calculated from seed sowing date to 70 % flowering of the whole plot and maturity days was taken as seed sowing date to 70 % maturity respectively. Similarly, plant height was measured from base of the plant to the final tip of the plant in centimeters, number of pod per plant was calculated by counting whole pod in a single plant, number of utilized pod per plant was counted based on the robustness of the pod per plant where only robust and viable pods were counted. In the same way, number of branches per plant was calculated by counting soybean branches per plant, and whole plot yield was measured in kilogram and converted into metric ton per hectare. The recorded data were fed up in the Microsoft Excel 2021 and analysis of variance in RCBD was done using STAR 2.0.1.

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Table1. Agrometeorological data of the experimental site in 2021/22

Month/Year	Mean Temperature (°C)		Total rainfall (mm)	Rainy days
	Maximum	Minimum		
July 2021	27.4	20.8	397.7	29
August 2021	27.4	20.6	215.8	26
September 2021	27.8	19.5	131.5	21
October 2021	26.8	16.8	31.2	8
November 2021	22.2	11.2	0	0
December 2021	16.6	4.2	45.2	3
January 2022	17.1	4.4	4.7	3
February 2022	17.7	4.4	50.0	3
March 2022	26.2	11.0	0.2	1
April 2022	28.4	15.2	28.8	6
May 2022	27.3	17.1	196.7	25
June 2022	28.2	20.0	204.0	22
Mean/Total	**24.4**	**13.8**	**1305.8**	**147**

RESULTS AND DISCUSSION

Yield attributing traits of coordinated varietal trial genotypes

The grain yield of soybean genotypes had significant differences from each other and the mean grain yield was 2357 kg/ha and 1896 kg/ha in 2018 and 2019 respectively (Tables 2 and 3).The highest yield was obtained from CN-60 (2858 kg/ha) followed by CM-9133 (2791 kg/ha) and lowest in LS-22-16-16 (1025 kg/ha) in 2018. Similarly, maximum yield was obtained from CM-9125 (2708 kg/ha) followed by G-1872 (2666 kg/ha) and lowest in TH-227 (667 kg/ha) in 2019.

Longest maturity days was recorded in LS-22-16-16 (140) and shortest in TH-227 (112) in 2018 and longest days took to maturity was SB0095 (128) and shortest was TH-227 (109) in 2019 respectively. Similarly, average number of pod per plant was 36 in 2018 and 51 in 2019. But maximum pod per plant was seen in Ankur (48) followed by CM- 9133 (45) and minimum in CM-9125 (27) in 2018 and maximum pod per plant was found in SB0095 (95) followed by Sathiya (89) but minimum in CN-60 and TH-227 (27) in 2019 respectively (Tables 2 and 3).

Thapa *et al.* (2014) also reported highly significant differences among the different traits grain yield, days to flowering, days to maturity, pod per plant etc. of soybean genotypes. They observed that Chaing Maw 60-63 performed better with highest yield (1889.9 kg/ha), early flowering (78 days) and medium number of pod per plant (56) in comparison with other genotypes.

Table 2. Growth and yield traits of soybean genotypes in the coordinated varietal trial (CVT) at Khumaltar, Lalitpur, Nepal in 2018

Genotypes	DF	ES	DM	Pl ht (cm)	Pods/Pl	Up/ Pl	Br/ Pl	Seeds/ Pods	GY (kg/ ha)
Ankur	72	19	129	96.47	48	6	3	2	2229
Chaing MOW 60-63	58	19	120	70.8	43	8	3	2	2512
CM-9106	56	17	122	83.27	28	6	2	2	2258
CM-9125	60	18	126	94.73	27	4	2	2	2175
CM-9133	57	20	118	55.96	45	8	2	2	2791
CN-60	58	20	118	62.87	36	4	2	2	2858
COLL#3	64	18	129	94.73	43	3	3	2	2441
G-1872	56	18	122	77.2	28	4	2	2	2700
G-1873	62	18	125	85.33	29	5	2	2	2060
G-4508	58	17	121	90.4	33	4	2	2	2535
GC-82234-22C	52	18	124	76.13	35	5	2	2	2666

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Japhe	61	19	127	91.93	42	4	4	2	2697
LS-22-16-16	53	17	140	76	33	4	3	2	1025
Ransom	54	19	120	73.47	37	5	3	2	2221
Sathiya	50	17	113	63.73	31	10	4	2	1375
SB0095	67	19	129	89.4	38	5	3	2	1991
TH-227	48	18	112	47.6	38	7	3	2	1704
VLS-I	50	18	115	58.4	32	6	3	2	1975
Mean	57.87	18.6	128.38	77.27	36.53	5.96	3	2	2357.3
CV (%)	8.27	12.75	39.5	11.27	20.7	41.54	22.13	4.1	14.99
P-value	0.00	0.99	0.59	0	0.03	0.03	0.00	0.23	0.00

DF: Days to flowering, ES: Early stand/m^2, DM: Days to maturity, Pl ht: Plant Height (cm), Pods/Pl: Pods per plant, UP/Pl: Utilized pods/plant, Br/Pl: Branches per plant, GY: Grain yield (kg/ha), CV: Coefficient of variation.

Table 3. Growth and yield traits of soybean genotypes in the coordinated varietal trial (CVT) at Khumaltar, Lalitpur, Nepal in 2019

Genotypes	DF	ES	DM	Pl ht (cm)	Pods/Pl	Up/Pl	Br/Pl	SW (g)	GY (kg/ha)
Ankur	56	48	116	76	42	5	3	33	1833
Chaing MOW 60-63	61	37	116	72	48	3	2	32	2250
CM-9106	56	52	116	86	61	14	4	35	1416
CM-9125	55	49	120	71	39	3	3	30	2708
CM-9133	55	50	116	76	48	3	3	35	1291
CN-60	49	44	119	70	27	1	3	30	2458
COLL#3	45	41	113	45	34	5	3	29	1333
G-1872	45	41	114	60	41	3	4	32	2666
G-1873	43	40	115	57	37	4	3	31	2451
G-4508	32	34	114	38	48	7	4	29	916
GC-82234-22C	57	48	115	93	61	9	3	33	1875
Japhe	55	49	120	99	56	7	3	28	2333
LS-22-16-16	59	52	120	94	78	9	3	35	1916
Ransom	53	45	118	66	37	9	4	29	1333
Sathiya	65	54	125	97	89	6	4	37	2500
SB0095	62	51	128	98	95	15	3	31	2083
TH-227	42	38	109	50	27	6	4	35	667
VLS-I	54	47	116	58	43	5	4	28	2000
Mean	52	46	118	73	51	6	3	32	1896
CV (%)	3.29	10.76	2.29	12.86	22.24	69.64	29.73	10.97	18.18
P-value	0.00	0.00	0.00	0.00	0.00	0.01	0.85	0.45	0.00

DF: Days to flowering, ES: Early stand/m^2, DM: Days to maturity, Pl ht: Plant Height (cm), Pods/Pl: Pods per plant, UP/Pl: Utilized pods/plant, Br/Pl: Branches per plant, GY: Grain yield (kg/ha), CV: Coefficient of variation.

Yield attributing traits of pre-released varietal trial genotypes

Maximum grain yield was achieved in LS-22-16-16 (2975 kg/ha) followed by Chaing MOW 60-63 (2925 kg/ha) and minimum yield was achieved in VLS-I (1900 kg/ha) in 2018. Similarly, the highest yield was recorded in G-4508 (3062 kg/ha) followed by COLL#3 (2625 kg/ha), and the lowest yield in VLS-I (1437 kg/ha) in 2019 (Tables 4 and 5). Genotype CM-9125 took 117 days to mature whereas GC-82234-22C and VLS-1 matured only in 109 days in 2018. In 2019, COLL#3 took 130 days to mature and shortest maturity days was recorded in GC-82234-22C (115) in 2019. Each year the seed per pod was nearly the same i.e. 2 only and average branches was 2 in 2018 and 3 in 2019 respectively (Tables 4 and 5).

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Similar results were reported by Neupane *et al.* (2014) who observed that AGS-361 (2991 kg/ha), AGS-378 (2011 kg/ha), AGS-377 (1982 kg/ha) were promising in terms of grain yield per hectare. Similarly, AGS-381 (1838 kg/ha) and AGS-364 (1779 kg/ha) produced higher yield than check variety Sathiya.

Table 4. Growth and yield traits of soybean genotypes in Pre-release varietal Trial (PRVT) at at Khumaltar, Lalitpur, Nepal in 2018

Genotypes	DF	ES	DM	SW (g)	Pl ht (cm)	Pods/ Pl	Br/Pl	Seeds/ Pod	GY (kg/ha)
Chaing MOW 60-63	53	17	115	34	27	2	3	2	2925
CN-60	55	46	115	33	33	2	2	2	2625
GC-82234-22C	31	48	109	27	20	4	1	2	2250
G-4508	49	40	114	31	18	2	1	2	2375
CM-9133	55	59	114	33	22	1	2	2	2650
LS-22-16-16	31	49	114	33	19	1	1	2	2975
VLS-I	30	54	109	27	16	3	2	2	1900
G-1873	61	56	116	27	23	3	2	2	2000
CM-9125	60	35	117	36	30	1	2	2	2200
COLL#3	64	54	112	32	26	6	2	2	2577
Mean	50	46	114	31	60	3	2	2	2448

DF: Days to flowering, ES: Early stand/m^2, DM: Days to maturity, Pl ht: Plant Height (cm), Pods/Pl: Pods per plant, Br/Pl: Branches per plant, GY: Grain yield (kg/ha), CV: Coefficient of variation.

Table 5. Growth and yield traits of soybean genotypes in Pre-release varietal Trial (PRVT) at at Khumaltar, Lalitpur, Nepal in 2019

Genotypes	DF	ES	DM	SW (g)	Pl ht (cm)	Pods/ Pl	Br/ Pl	Seeds/ Pod	GY (kg/ha)
Chaing MOW60-63	55	20	116	35	62	39	2	2	2250
CN-60	58	27	116	33	65	53	3	2	2375
GC-82234-22C	48	23	115	29	72	38	3	2	2500
G-4508	51	27	118	31	71	88	5	2	3062
CM-9133	57	26	117	34	90	54	4	2	2500
LS-22-16-16	46	20	116	31	62	61	2	2	2500
VLS-I	47	21	123	32	45	50	3	2	1437
COLL#3	65	22	130	38	92	98	6	2	2625
Mean	53.38	23.25	118.88	32.88	69.88	60.13	3.5	2	2406

DF: Days to flowering, ES: Early stand/m^2, DM: Days to maturity, SW: 200 seed weight (g), Pl ht: Plant height (cm), Pods/Pl: Pods per plant, Br/Pl: Branches per plant, GY: Grain yield (kg/ha), CV: Coefficient of variation.

The combined analysis of pre-released varietal trial data of the year 2018 and 2019 showed that grain yield was maximum for the genotype LS-22-16-16 (2737.5 kg/ha) followed by G-4508 (2718.5 kg/ha) and minimum for VLS-I (1668.5 kg/ha). Days to flowering (64) and maturity (121) were longest for COLL#3 and shortest flowering days was recorded in LS-22-16-16 (38) and maturity in GC-82234-22C (112) respectively (Table 6). Seed weight was found maximum of 35 gram for Chaing MOW 60-63 and COLL#3. However, branches per plant (3) and seeds per pod (2) was almost the same for all the genotypes (Table 6). Based on the combined data it clearly indicates that LS-22-16-16 and G-4508 are best genotype for release a variety for the benefit of the mid-hill based farmers.

Manandhar (2021) reported that LS-77-16-16, Karver local, F-778817, TGX-311- 23D and IARS-871, IangBeakong, G 4504 and G 1871 were promising genotypes that can be used for formers general cultivation purposes. Similar type of result was also reported by Pokhrel *et al.* (2021) who found that SBO-115 (1912 kg/ha) and TGX1990-94F (1883 kg/ha) produced

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significantly highest yield under flooded and normal conditions. These two cultivars also possessed highest value of yield index.

Table 6. Pooled mean value of yield attributing traits of soybean genotypes at Khumaltar, Lalitpur, Nepal (2018 and 2019)

Genotypes	DF	ES	DM	SW (g)	Pl ht (cm)	Br/Pl	Seeds/ Pods	GY (kg/ha)
Chaing MOW 60-63	54	37	116	35	44.5	3	2	2587.5
CN-60	56	73	116	33	49	3	2	2500
GC-82234-22C	39	71	112	28	46	2	2	2375
G-4508	50	67	116	31	44.5	3	2	2718.5
CM-9133	56	85	116	34	56	3	2	2575
LS-22-16-16	38	35	115	32	40.5	2	2	2737.5
VLS-I	38	38	116	30	30.5	3	2	1668.5
COLL#3	64	76	121	35	59	4	2	2601
Mean	52	69	116	32	64.5	3	2	2427

DF: Days to flowering, ES: Early stand/m^2, DM: Days to maturity, SW : 200 seed weight (g), Pl ht: Plant height (cm), Br/Pl: Branches per plant, GY: Grain yield (kg/ha), CV: Coefficient of variation.

CONCLUSION

The coordinated varietal trial and pre-released varietal trial genotypes showed tremendous varietal differences among themselves. These genotypes showed differences in terms of grain yield, pod per plant, flowering and maturity days, seed weight, plant height etc. Some genotypes were promising and few were low yielding. Promising genotypes can be promoted as farmers' acceptance test and prepare the proposal of varietal release.

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Authors' contributions

PKS was lead investigator for this experiment. PKS and UKSK wrote the manuscript. JS edited the manuscript. All authors listed have approved it for publication.

Conflict of interest

The authors declare no conflict of interests regarding the publication of this manuscript.

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