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INFLUENCES OF DIFFERENT VARIETIES AND FERTILITY SCHEDULES ON GROWTH AND PRODUCTIVITY OF SOYBEAN (*GLYCINE MAX L.*) IN VERTISOLS OF CENTRAL INDIA

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ABSTRACT

In the present study the experiment was carried out to study the effect of fertilizers at different level and performance of the twelve Soybean varieties viz., PK 472, JS 335, JS 93 05, JS 71 05, JS 95-60, NRC 2, NRC 7, NRC 12, NRC 37, PK 1024, MACS 330, and MAUS 47 were tested under five fertility levels viz., F_0: $N_0P_0K_0$, F_1: $N_{20}P_{60}$, F_2:$N_{20}K_{20}$, F_3: $P_{60}K_{20}$ and F_4: $N_{20}P_{60}K_{20}$. The significant increase in seed yield of soybean was noticed with the various fertility levels. The yield ranges from 1435 to 2029, 1771 to 2299, 1772 to 2177, 1914 to 2369 and 1994 to 2752 at different fertilizer level. It was also observed that the traits like plant height ((57.20 cm), number of pods per plant (52.16), seed yield (2149 kg/ha), stover yield (2407 kg/ha) and B:C ratio (2.308) performed significantly superior at F4 : N20P60K20 fertilizer level similarly, the varieties such as NRC 37, JS 95-60, NRC 7, JS 93-05 and MACS 330 also performed significantly more as compared to the other fertilizer levels..

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INTRODUCTION

Soybean [*Glycine max* (L.) Merril] is the *numerouno* oilseed crop and has established itself as an important oil seed crop in India in a very short period (Krishnan, 2000). It is now becoming important and valuable crop of all countries because it is a major source of protein, energy, polyunsaturated fat, fibers, vitamins, minerals, both of humans and livestock (Singh and Ghosh, 2003). Soybean is predominantly grown as rainfed crop in *Vertisols* and associated soils with an average seasonal rainfall of 900 mm which varies greatly across locations and years. These soils are potentially productive, if managed properly in terms of overcoming soil, water and nutrient management constraints (Singh *et al.,* 2012). Currently, these soils have low and skewed crop productivity. There is a considerable potential to bridge the yield gap between the actual and potential yield through adoption of appropriate improved resource management strategies. It now calls to view the problem in holistic manner to develop farmers' friendly soil, water, nutrient and crop management technology where in there is a substantial improvement of nutrient use efficiency of applied nutrients and also have an understanding of indigenous nutrient supply parameter and to identify suitable varieties for either cultivation or utilizing in breeding programme for harnessing sustainable soybean production and conserving natural resources. (Cassman *et al.,* 1996) Plants must be supplied adequately with nutrients during the critical growth period for the normal maintenance of their physiological and biochemical processes. For this reason obviously, the concentration of plant nutrients in the soil solution must be maintained at a satisfactorily level for optimum plant growth. Therefore, nutrient availability depends not only on the nutrient concentration in soil solution, but also on the ability of the soil to maintain the nutrient concentration (Mengel and Kirkby, 1987). Since the farmers of this region are largely cash - limited, which restricts their capacity to buy fertilizers, it is important to develop production systems that are more nutrient-use efficient. Synchrony of nutrient supply with crop requirements and optimum utilization of applied nutrients are a practical ways to achieve nutrient use efficiency which varies from genotype to genotype (Sharma *et al.,* 2013, Shankerlal Khaswa *et al.,* 2014). Keeping all the consideration in mind the study was under taken to evaluate the cultivars of Soybean at different fertilizer level and to study nutrient management strategy for soybean in Malwa plateau of Madhya Pradesh.

MATERIALS AND METHODS

The field experiment was conducted during *kharif* 2010 and 2011 at ICAR-Indian Institute of Soybean Research, Indore (Madhya Pradesh). Indore is situated at 22º 72' 0" N, 75º86' 0" E, and perched at 550 meters above the mean sea level. The climate of Indore is humid sub-tropical with a dry season from early October to mid June and then wet season up to the early October. May and June are the hottest months when mean maximum temperature reaches up to 48ºC and winter are

cold when average minimum temperature falls down to 7ºC during December and January months. Relative humidity is highest in July-mid September (about 90%) and lowest in April-May (about 40%). Sowing of the soybean was done at the seed rate of 80 kg/ha. The fertilizers were applied before sowing as basal per the treatments. The row to row distance of 45 cm and plant to plant distance of 4-5 cm was maintained for obtaining the desired plant population. Twelve Soybean Varieties viz., PK 472, JS 335, JS 93 05, JS 71 05, JS 95-61, NRC 2, NRC 7, NRC 12, NRC 37, PK 1024, MACS 330, and MAUS 47 were tested under five fertility levels viz., F_0: $N_0P_0K_0$, F_1: $N_{20}P_{60}$, F_2 : F_0: $N_{20}K_{20}$, F_3: $P_{60}K_{20}$ and F_4 : $N_{20}P_{60}K_{20}$ in Factorial Randomized Block Design with four replications. All the recommended package of practices were followed for healthy crop growth and traits like Plant height, Dry matter/plant, Pods per plant, leaf area index, Seeds per pod, Seed Index (weight of 100 seeds), Seed yield, Stover yield per hectare, Harvest index (HI) were measured on 5 randomly chosen plants from each plot. Data were analyzed in excel sheet using various formulas and calculations.

RESULTS AND DISCUSSION

Significant differences for all the characters were observed among varieties and also at different fertilizer level indicating the effect of different fertilizer doses and response of cultivars to different doses of fertilizers. (Table 2).

Plant height

Soybean height significantly varied with the varieties during both the years of study and also in the pooled data (Table 2). The tallest plants were recorded with NRC 37 (71cm) followed by JS 93-05 (64.03 cm) and MAUS 47 (61.40 cm). The significant increase in plant height was noticed with the fertility levels. The maximum plant height of soybean (57.37, 57.03, 57.20 cm) was recorded with $N_{20}P_{60}K_{20}$ during 2010, 2011and pooled data, respectively. The height of the any genotype is governed by its genetic constituents and perceptible variation occurred among the varieties. Similar views were also expressed by Mahamood *et al*. (2009). Similar findings were also reported by Dubey and Vyas (2010), Mohad *et al*. (2010) and Nagaraju and Mohan Kumar (2010).

Dry matter accumulation

Dry matter accumulation linearly increased with the advancement in the crop age (Table 1). Soybean plant dry matter accumulation was significantly influenced by the varieties as well as fertility levels during both the years as well as in the pooled analysis at all the stages of crop growth stages. Significantly highest dry matter accumulation was recorded with NRS 37 followed by JS 95-60. The highest dry matter accumulation was observed in case of $N_{20}P_{60}K_{20}$ followed by N20 P60 at all the sampling dates. The interaction effects were significant at 45 and 60 DAS as well as at harvest during 2010, 2011 and pooled analysis. The highest dry matter accumulation was noticed with NRC 37 under fertility level $P_{60}K_{20}$ at 45, 60 DAS and at harvest during both years as well as in pooled data.

Leaf area index (LAI)

The leaf area index increased as the age of crop advanced. The maximum LAI was recorded with NRC 37 and JS 95-60 followed by MAUS 47 and fertility doses of $N_{20}P_{60}K_{20}$ followed by $N_{20}P_{60}$ during 2010, 2011 and in the pooled analysis of data at all the stages of observation (Table 3) (Graph 1). The interaction effect of soybean varieties and fertility levels on LAI of soybean was found to be significant during both the years

Table 1: Dry matter accumulation in soybean as influenced by different varieties and fertility levels at various stages of crop

Treatment	Dry matter accumulation (g/plant)											
	30 DAS			45 DAS			60 DAS			At harvest		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
Variety												
PK 472	1.81	2.52	2.16	8.48	9.43	8.96	14.91	15.39	15.15	26.93	27.37	27.15
JS 335	2.10	2.78	2.44	9.81	11.62	10.71	16.77	18.24	17.51	27.60	27.62	27.61
JS 93-05	2.32	2.98	2.65	6.70	6.20	6.45	12.88	13.97	13.42	21.59	20.72	21.16
JS 95-60	2.58	3.00	2.79	10.72	11.99	11.35	17.90	19.22	18.56	28.07	27.96	28.02
JS 71-05	2.06	2.43	2.25	5.74	6.25	6.00	11.29	10.99	11.14	19.66	20.81	20.24
NRC 2	2.25	2.29	2.27	7.90	10.23	9.07	14.20	16.30	15.25	25.59	27.30	26.44
NRC 7	2.39	2.78	2.59	6.93	7.66	7.29	12.60	12.99	12.80	22.53	22.38	22.46
NRC 12	1.95	2.50	2.23	6.01	7.54	6.78	11.42	12.68	12.05	19.38	22.00	20.69
NRC 37	2.45	2.88	2.67	12.00	13.38	12.69	20.02	21.12	20.57	28.77	29.81	29.29
PK 1024	2.11	2.47	2.29	6.44	7.71	7.08	12.06	13.13	12.60	21.48	22.55	22.02
MACS 330	2.13	2.52	2.33	9.12	9.21	9.16	15.73	14.97	15.35	23.85	21.36	22.61
MAUS 47	1.80	2.23	2.02	10.05	11.77	10.91	16.97	18.35	17.66	26.41	27.76	27.08
SEm ±	0.07	0.08	0.05	0.19	0.23	0.16	0.26	0.31	0.20	0.54	0.56	0.40
CD (p=0.05)	0.15	0.18	0.12	0.44	0.54	0.37	0.61	0.73	0.47	1.25	1.30	0.93
Fertility level (kg/ha)												
$N_0P_0K_0$	1.86	2.24	2.05	6.54	8.27	7.41	12.22	13.74	12.98	19.85	21.87	20.86
$N_{20}P_{60}$	2.25	2.66	2.45	8.87	9.49	9.18	15.56	15.84	15.70	25.85	25.01	25.43
$N_{20}K_{20}$	2.09	2.54	2.31	7.98	8.96	8.47	14.12	14.57	14.34	23.57	23.31	23.44
$P_{60}K_{20}$	2.19	2.68	2.43	8.00	9.84	8.92	14.18	15.73	14.95	23.65	25.69	24.67
$N_{20}P_{60}K_{20}$	2.43	2.96	2.70	9.39	10.51	9.95	16.18	16.94	16.56	27.41	27.31	27.36
SEm ±	0.04	0.05	0.03	0.12	0.15	0.10	0.17	0.20	0.13	0.35	0.36	0.26
CD (p=0.05)	0.10	0.12	0.08	0.28	0.35	0.24	0.40	0.47	0.31	0.81	0.84	0.60
CV (%)	13.46	13.48	9.42	10.31	11.03	8.05	8.10	9.09	6.08	9.18	9.36	6.75

Table 2: Yield and yield contributing traits of soybean under various fertilizers doses

Treatment	Plant height (cm)			Number of podsper plant			Seed yield (kg/ha)			Stover yield (kg/ha)			Net returns (Rs/ha)			B: C ratio		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
Variety																		
PK 472	52.57	51.93	52.25	32.16	47.60	39.88	1607	1948	1777	1853	2326	2089	15553	30124	22838	1.687	2.291	1.989
JS 335	58.94	62.18	60.56	32.79	53.94	43.37	1796	2139	1967	2019	2484	2252	19961	35205	27583	1.882	2.509	2.196
JS 93-05	63.93	64.12	64.03	40.92	49.34	45.13	1894	2217	2056	2195	2627	2411	22391	37941	30166	1.990	2.631	2.311
JS 95-60	34.00	36.92	35.46	41.00	54.46	47.73	1988	2225	2107	2315	2568	2442	24647	37528	31087	2.085	2.608	2.347
JS 71-05	39.27	36.87	38.07	31.90	26.87	29.39	1751	1942	1847	1969	2256	2113	18906	29834	24370	1.836	2.283	2.060
NRC2	50.27	54.95	52.61	38.96	24.01	31.49	1841	1877	1859	2136	2167	2151	21144	28029	24587	1.937	2.206	2.071
NRC 7	44.54	43.43	43.98	34.38	31.69	33.04	1869	2139	2004	2195	2474	2334	21851	35200	28526	1.967	2.513	2.240
NRC 12	39.81	42.72	41.26	40.15	37.80	38.97	1834	1842	1838	1951	2263	2107	20705	27354	24030	1.917	2.177	2.047
NRC 37	71.11	70.90	71.00	49.37	56.52	52.95	2209	2442	2325	2348	2623	2486	29545	43065	36305	2.305	2.849	2.577
PK 1024	42.43	43.83	43.13	35.54	47.21	41.37	1744	1959	1852	1989	2304	2147	18789	30363	24576	1.832	2.306	2.069
MACS 330	55.80	50.39	53.09	38.78	26.61	32.70	1909	1903	1906	2094	2383	2238	22576	29105	25840	2.001	2.252	2.126
MAUS 47	60.26	62.55	61.40	38.91	50.88	44.89	1654	2026	1840	1824	2112	1968	16560	31654	24107	1.733	2.359	2.046
SEm ±	0.88	0.96	0.66	1.13	3.22	1.67	29.2	39.0	25.8	31.5	38.4	25.1	646.91	963.85	613.62	0.029	0.041	0.026
CD (p=0.05)	2.06	2.24	1.55	2.63	7.54	3.91	68.3	91.2	60.4	73.6	89.7	58.7	1513.20	2254.55	1435.33	0.067	0.096	0.062
Fertility level (kg/ha)																		
N0 P_0K_0	43.21	46.19	44.70	27.04	32.19	29.61	1648	1773	1711	1906	2134	2020	17856	26669	22262	1.840	2.216	2.028
$N_{20}P_{60}$	54.81	53.39	54.10	43.32	45.69	44.51	1892	2116	2004	2127	2435	2281	20799	33806	27302	1.895	2.415	2.155
$N_{20}K_{20}$	49.91	49.09	49.50	34.44	39.7	37.07	1777	2014	1896	2016	2343	2179	20408	32673	26540	1.940	2.460	2.200
$P_{60}K_{20}$	50.09	52.96	51.52	39.08	47.34	43.21	1857	2113	1985	2087	2421	2254	21558	33899	27728	1.929	2.421	2.175
$N_{20}P_{60}K_{20}$	57.37	57.03	57.20	51.07	53.26	52.16	2033	2266	2149	2235	2579	2407	24641	37705	31173	2.051	2.565	2.308
SEm ±	0.57	0.62	0.43	0.73	2.08	1.08	18.9	25.2	16.7	20.3	24.8	16.2	417.58	622.16	396.09	0.018	0.027	0.017
CD (p=0.05)	1.33	1.44	1.00	1.7	4.87	2.53	44.1	58.9	39.0	47.5	57.9	37.9	976.77	1455.31	926.50	0.043	0.062	0.040
CV (%)	7.71	8.27	5.75	12.92	33.03	18.12	7.1	8.5	5.9	6.8	7.2	5.0	13.74	13.08	10.16	6.61	7.61	5.43

Table 3: Leaf Area Index of soybean under different varieties and fertility levels at various stages of crop

Treatment	Leaf area index											
	30 DAS			45 DAS			60 DAS			At harvest		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
Variety												
PK 472	1.09	1.15	1.12	2.38	2.96	2.67	4.33	4.57	4.45	4.23	4.09	4.16
JS 335	1.21	1.38	1.29	2.64	3.58	3.11	4.89	5.50	5.20	4.74	4.80	4.77
JS 93-05	0.80	0.82	0.81	1.75	2.11	1.93	3.25	3.21	3.23	3.50	3.69	3.59
JS 95-60	1.32	1.42	1.37	2.91	3.66	3.29	5.21	5.71	5.46	4.85	4.90	4.88
JS 71-05	0.70	0.81	0.76	1.51	2.09	1.80	2.79	3.21	3.00	3.20	2.90	3.05
NRC2	1.05	1.22	1.13	2.27	3.14	2.71	4.18	4.81	4.49	4.03	4.33	4.18
NRC 7	0.93	0.96	0.95	1.99	2.46	2.22	3.66	3.83	3.75	3.62	3.40	3.51
NRC 12	0.83	0.95	0.89	1.79	2.45	2.12	3.28	3.77	3.53	3.21	3.36	3.29
NRC 37	1.45	1.58	1.52	3.22	4.05	3.63	5.89	6.25	6.07	4.87	4.90	4.88
PK 1024	0.87	0.98	0.93	1.91	2.50	2.20	3.48	3.84	3.66	3.41	3.41	3.41
MACS 330	1.15	1.13	1.14	2.51	2.87	2.69	4.57	4.46	4.52	4.42	3.97	4.19
MAUS 47	1.25	1.39	1.32	2.70	3.58	3.14	4.99	5.50	5.25	4.30	4.29	4.29
SEm ±	0.02	0.02	0.02	0.04	0.06	0.04	0.08	0.09	0.06	0.08	0.08	0.05
CD (p=0.05)	0.04	0.05	0.04	0.10	0.13	0.09	0.18	0.21	0.14	0.18	0.20	0.13
Fertility level (kg/ha)												
$N_0P_0K_0$	0.90	1.03	0.96	1.95	2.64	2.30	3.55	4.09	3.82	3.42	3.58	3.50
$N_{20}P_{60}$	1.12	1.18	1.15	2.47	3.06	2.77	4.50	4.70	4.60	4.31	4.13	4.22
$N_{20}K_{20}$	1.03	1.10	1.06	2.25	2.79	2.52	4.13	4.33	4.23	3.93	3.75	3.84
$P_{60}K_{20}$	1.04	1.17	1.11	2.25	3.05	2.65	4.13	4.63	4.38	3.93	4.12	4.03
$N_{20}P_{60}K_{20}$	1.18	1.27	1.22	2.57	3.23	2.90	4.74	5.03	4.88	4.56	4.42	4.49
SEm ±	0.01	0.01	0.01	0.03	0.04	0.02	0.05	0.06	0.04	0.05	0.05	0.04
CD (p=0.05)	0.03	0.03	0.02	0.06	0.09	0.05	0.12	0.14	0.09	0.12	0.13	0.08
CV (%)	8.11	8.67	6.10	8.32	8.59	6.19	8.21	8.97	6.05	8.48	9.31	6.08

as well as in the pooled analysis at 60 DAS in 2011.Maximum soybean LAI was observed with NRC 37 and $P_{60}K_{20}$ at 30, 45 and 60 DAS in both the years and in the pooled analysis of the data except at 45 DAS in 2010, which was highest with NRC 37 and $N_{20}P_{60}$.While at harvest stage, significantly higher LAI was noticed with combination of JS 95-60 and MACS 330 and $N_{20}P_{60}K_{20}$ in the year 2010 but in 2011, highest LAI was noticed with JS 335 in $P_{60}K_{20}$.

Number of pods/ plant

The number of pods per plant was recorded higher with NRC 37 followed by JS 95-60 in both the years and pooled data. It is due to the fact that different varieties are having different genotypic/phenotypic characters. Mahamood *et al*. (2009) observed that number of branches and pods per plant differed significantly among varieties. Similar findings were also reported by Neves *et al*. (2013) and Kandil *et al*. (2012). The highest number of pods per plant in soybean (51.07, 53.26 and 52.16) was noticed with $N_{20}P_{60}K_{20}$ in the year 2010, 2011 and in the pooled analysis of the data. Under the interaction effects of soybean varieties and nutrient management, the highest pods per plants were recorded under the treatment combination of $N_{20}P_{60}K_{20}$ with NRC 37 followed by JS 95-60, however the differences were found to be non-significant during 2011.(Veer and Thenua, 2011)

Number of seeds/pod

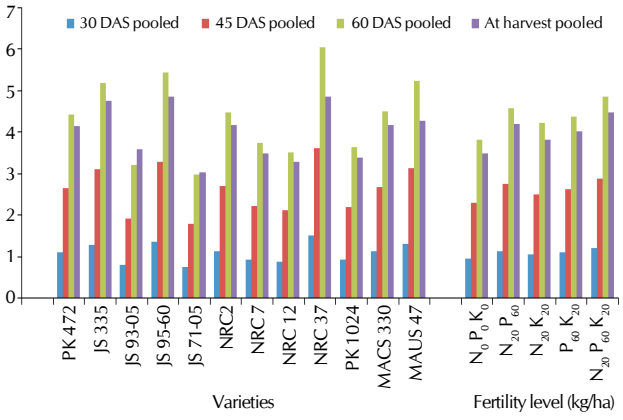
The number of seeds per pod of soybean revealed non-significant change with soybean varieties as well as fertility levels. It is due to the most of the varieties of soybean are having more or less same number of seeds as well as seed index.

Seed index

The seed index was significant change in soybean due to soybean varieties, whereas, non-significant effect was observed among the fertility levels and interaction of varieties and fertility doses during both the years as well as in the pooled analysis of the data over years. Highest seed index of soybean (13.52, 13.66 and 13.59) was under NRC 7 which was significantly superior to other varieties under study.

Yield

The seed and Stover yield of soybean significantly varied with the varieties during both the years of study and also in the pooled data (Table 2).The maximum seed yield was recorded with NRC 37 followed by JS 95-60 during both the years as well as in the pooled analysis. Similarly the maximum Stover



Graph 1: Leaf Area Index of soybean under different varieties and fertility levels at various stages of crop

yield was recorded with NRC 37 followed by JS 95-60 during 2010 as well as in the pooled analysis. The significant increase in seed yield of soybean was noticed with the fertility levels. The increase in soybean yield was to the tune of 14.8, 7.8, 12.6 and 23.3 and 19.4, 13.6, 19.2 and 27.8 % by the addition of different doses of NP, NK, PK and NPK respectively as compared to control in the year 2010 and 2011, respectively. However, the yield difference between NP and PK remained at par (Kumawat *et al.,* 2016). Similar trend were notice in case of pooled analysis where17.1, 10.8, 16.0 and 25.6 % increase in seed yield were observed due to application of NP, NK, PK and NPK respectively as compared to control. (Dubey, 2001, Patel *et al.,* 2015) The higher yield with all the three major nutrients showed their essentiality for the productivity of the crop. The application of all the three nutrients has synergistic effect on nutrient uptake which resulted in higher yield. The appropriate dose of application fulfills the plant nutrient requirement. Similar observations was also reported by Shafii *et al*. (2011), Mahamood *et al*. (2009) and Kandil *et al*. (2012). Dubey (2001) reported that the application N: P: K at 20:80:20 kg/ha produced the highest yield, which was 8.86 and 23.27% higher than that in N:P:K at 10:40:10 and 0:0:0 kg/ha respectively.

The interaction effect of soybean varieties and fertility levels on soybean seed yield was found to be significant during both the years as well as in the pooled analysis. Highest seed yield of soybean was recorded under the combination of variety NRC 37 and $N_{20}P_{60}K_{20}$, 2662.09, 2841.59 and 2751.84 kg/ha respectively during 2010, 2011 and in the pooled analysis, which is followed by the combination of variety NRC 37 and $P_{60}K_{20}$.

Variety NRC 37 gave the higher values of the growth characters (plant height, number of pods, number of seeds) ultimately increasing the productivity of soybean. In case of total system productivity was noticed with the fertility levels. The increase in productivity was to the tune of 13.83, 20.08 and 16.92 % (NP), 9.76, 15.42 and 12.54 % (NK), 11.21, 18.20 and 14.67 % (PK) and 20.94, 20.65 and 22.76 % (NPK) by the addition of different doses of NP, NK, PK and NPK respectively as compared to control during in pooled data analysis.

The above study indicates that a wide varieties in growth, nutrients, use efficiencies and productivity among different soybean genotypes and nutrients management strategies and subsequent impact on soybean crop. It was also concluded that the genotypes NRC 37, JS 95-60, NRC 7, JS 93-05 and MACS 330 performed superior and integration with $N_{20}P_{60}K_{20}$ can be recommended for sustainable soybean cropping system.

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