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Influence of IPNS on crop growth rate, nutrient contents and their intake by seed and Stover in corn

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Abstract
Corn seeds have high nutritive values and used as food while its stover is used as fodder, feed and fuel therefore, Its demand is increasing day by day. Thus, for higher soil productivity and vigorous fertility for longer run, the importance of integrated plant nutrient management system (IPNS) has increased. Inspite of higher and sustaining crop yield, fertilizer and manure management in corn crop production is also desirable for environmental reasons. The aim of present investigation was to study the "Influence of IPNS on Crop Growth Rate, N_2, P_2O_5, K_2O contents and their intake by seed and stover in corn." Results showed that the crop growth rate (CGR) of corn was more at knee high to tasseling stage, which gradually declined towards the maturity during both the years of experimentation. Significant increase in CGR was recorded in treatments receiving organic, inorganic and bio-fertilizer sources of nutrients in combination. N_2, P_2O_5 and K_2O content and their intake in corn seed and stover obtained highest under treatment T_3 (FYM + Chem.) followed by T_8 (*Azotobactor* + *Rhizobium* + PSB + Chem.) and T_7 (*Azotobacter* + *Rhizobium* + PSB + Chem.) which were significantly superior to other treatments during both the years of investigation. The substitution of a part of inorganic fertilizer by organic sources and bio-fertilizers is the best approach to improve soil health for sustainable crop production. By adopting integrated plant nutrient supply we can get maximum yield with higher economic returns without causing soil pollution and spoiling soil health on long term basis.

Keywords: IPNS, Crop Growth Rate, NPK, Corn

Introduction
Corn occupies an important position in the world economy and trade as a food, feed and an industrial grain crop. Several million people in the developing world consume corn as a principal staple food and derive their protein and about 16 to 56% of the total daily calories requirements from it. Thus, for higher productivity and improvement in soil fertility for longer period, integrated plant nutrient management system (IPNS) has become important aspect. IPNS efficiently and judiciously uses all the major sources of plant nutrients in an integrated manner to get maximum economic yield without any deleterious effects on properties of the soil. Inspite of higher and sustaining crop yield, fertilizer and manure management in crop production is also desirable for environmental reasons. Hussain and khan (1973) [3] reported that all strains of corn cv. JI with inoculation tended to increase the nutrient content of seeds and stover. Sikilar (1974) [10] reported that under field conditions, single strain inoculum of *Azotobacter* was found more effective as regard to N intake in corn as compared to multiple strain inoculum. Meshram and Shande (1982) [5] observed that total nitrogen intake by corn after inoculation and moderate application of N fertilizer and FYM increased significantly and resulted in higher N concentration in seed and stover. Wedad *et al*. (1988) [15] observed that the inoculation with *A. chroococcum* had the greatest effect on plant nitrogen content. The beneficial effects of *Azotobacter* are related not only to their N fixing efficiency but also with their ability to produce antibacterial and antifungal compounds, growth regulators and siderophores. Milic *et al*. (1998) reported that presence of *Azotobacter chroococcum* increased nitrogen content and intake in corn. Brar *et al.* (2001) [2] observed that application of NPK in corn (*Zea mays* L.) with and without farmyard manure, crop nutrient intake (nitrogen, phosphorus and potassium) increased significantly with the rise in soil fertility status. Reddy *et al*. (1977) [9] showed, seed inoculation with *Azotobacter* increased the seed yield of corn by 9 to 14% and yield was also increased with increased in applied N upto 150 kg ha^{-1}. They also observed that nitrogen rate and *Azotobacter* inoculation effect was non-significant. Singh *et al*. (1989) [11] reported that incorporation of FYM at 10-11.5 t ha^{-1} along with optimum rate of NPK increased the yield of corn by 0.8-1.5 t ha^{-1} over the optimum nutrient input. Mishra *et al*. (1995) registered an increase in seed yield of corn by 37.6 and 31%, respectively by *Azotobacter* + VAM and PSB in plots receiving no fertilizer as compared with control. Seed yield was highest with application of NPK + *Azotobacter*, while 25% increase in yield by

using *Azotobacter*, VAM, and PSB as compared with application of NPK alone. Suri *et al.* (1995) [14] reported that corn production was highest in the plots which were treated with 90 kg N + 45 Kg P_2O_5 + 20 Kg K_2O along with 10 t ha^{-1} FYM. (Manna and Hazra, 1996) Application of cow dung slurry @ 5 t ha^{-1} + rock phosphate @ 50 Kg P_2O_5 ha^{-1} along with *Azotobacter chroococcum* and *Aspergillus awamori* (PSB) resulted maximum seed yield and net profit of corn as compared to compost alone or *at par* with 100% recommended dose of NPK. Rameshwar *et al.* (1998) [8] observed that effect of FYM application was seen as direct and cumulative effect on corn and on wheat crop, respectively over rest of the treatment. Singh *et al.* (1999) [12] reported that the optimal dose of NPK + FYM increased seed and stover yield of corn over rest of the combinations. Balyan *et al.* (2000) [1] observed that corn stover management did not affect seed yield of wheat. 100 kg N + 40 kg P_2O_5 resulted in considerable higher corn yield than of 50 kg N and 40kg P_2O_5 ha^{-1} applied under corn-wheat cropping system. However, systematic/scientific research findings are meager on several aspects of IPNS in corn. Therefore, the present study entitled "Influence of IPNS on Crop Growth Rate, N_2, P_2O_5, K_2O contents and their intake by seed and stover in corn" was under taken.

Material and method

Present experiment titled **"**Influence of IPNS on Crop Growth Rate, N_2, P_2O_5, K_2O contents and their intake by seed and stover in corn" was conducted during the summer season at the Agricultural Research Farm of Amar Singh (P.G.) College, Lakhaoti (Bulandshahar). The details of the material and method adopted during the course of investigation are described below.The experiment was conducted at the Agricultural Research Farm of Amar Singh (P.G.) College, Lakhaoti, Bulandshahar, is located in western U.P., the most fertile and suitable belt of tract between the Ganga and the Yamuna. It lies between 27.09^0 N latitude and 77.02' E longitude at an elevation of about 202.47 meter above mean ocean level. The monsoon commences during the last week of June or first week of July and continues up to 15th of September. The average annual rainfall of region was 603.74 mm about 88% of which was received from June to September and the remaining (20%) during October to March. During May and June months of the year maximum temperature was ranged between 42-44^{0}C while during January the minimum temperature ranged between 3.0-6.0^{0}C. Just after the emergence of first tassel, count for number of tassels bearing plants was made on alternate days. The date by which 75 percent plants had tassels was recorded as days taken to 75 per cent tasseling. Just after the emergence of first silk, field counts for number of silk bearing plants were made on alternate days. The date by which, 75 percent of the plants had silk was recorded as days taken to silking. Maturity date was recorded when the cob husk turned brown yellow and most of the leaves on the plant turned yellow brown. The total number of days from sowing to maturity was reported as days taken to maturity.Statistical analyses were carried out for analysis of variance (ANOVA) by method as given by Cochran & Snedecor (1984) [13].

Result and Discussion

Crop growth rate

Crop growth rate was highest (4.08 during 1st and 4.13 g plant/day during 2nd year) at knee height stage to tasseling stage under the treatment T_3 (FYM + Chemical fertilizer) which was significantly higher over rest of the treatments during both the years. At knee high to tasseling period, CGR varied significantly in T_3 due to combined use of [FYM + chemical fertilizer (4.08 g/plant/day)] and all the sources of nutrients applied together (T_8) (3.78 g/plant/day) over combined use of other sources during 1st, while in 2nd year and in average values T_3 recorded significantly more CGR with 4.11 g/plant/day, respectively over other treatments. At tasseling to silking period, combined use of various sources of nutrients recorded statistically par with CGR values among each other but proved significantly superior to T_2 (Test value) and T_9 (Vermicompost + chemical fertilizer) treatment in 1st while CGR values obtained under T_3, T_9, and T_1 were statistically similar amongst themselves but superior to other treatments in 2nd year while T_3 (FYM + Chemical fertilizer), T_8 (Azoto + Rhizo + PSB + FYM + Chemical fertilizer), T_7 (Azotobactor + Rhizo + PSB + Chemical fertilizer) and T_4 (Azoto + Chemical fertilizer) treatments recorded CGR values *at par* with each other in average data. During 2nd year at silking to milky period, T_9 showed maximum GGR which was closely followed by T_6 (PSB + Chemical) and T_5 (Rhizo + Chemical fertilizer) and recorded significant superiority to rest of the treatments. The effect of various treatments on CGR was found non-significant during 1st year as well as in average mean also. The minimum CGR of 1.85 g/plant/day was observed with T_3. At milky to harvest period, maximum CGR was observed in T_3 (0.85 in 1st, 0.72 in 2nd year and 0.79 in average values), while it was *at par* with T_7 and T_8 in 2nd year and T_3, T_1, T_6 and T_9 in average data but significantly superior to rest of the treatments. T_8 resulted in minimum CGR (0.22 g/plant/day) (Table 2) (Figure 2).

N_2 content and intake in corn

N_2 content in corn seed and stover as well as its full intake due to integrated plant nutrient supply treatments during 1st and 2nd year is presented in Table 3 (Figure 3). During both the years differences in N_2 content in corn seed and stover also its intake due to IPNS treatments were found significant and in average values. Integrated use of Azotobactor + Rhizobium + FYM + PSM + Chemical fertilizer (T_8) and Azotobactor + Chemical fertilizer (T_4) found statistically par with N content in seed and stover of corn during both the years. These treatments found superior to the other remaining treatments. The lowest values of N_2 content was found with T_9 (Vermicompost + Chemical fertilizer 1.290% in seed and 0.680% in stover in 1st and 1.300% seed and 0.680% in stover in 2nd year). Respective to N_2 intake in seed and stover of corn, T_3 showed significantly higher N_2 intake (77.60 kg/ ha in seed and 58.31 kg / ha in stover during 1st year and 81.14 kg ha^{-1} in seed and 60.19 kg / ha in stover during 2nd year than rest of the treatments in both the years of experimentation and in their average values also. The minimum average value (seed 42.90 kg / ha and stover 27.40 kg/ ha) of N intake was obtained in T_9 treatment (Table 3) (Figure 3).

P_2O_5 content and intake in corn

P_2O_5 content and intake in corn seed and stover were affected significantly due to various IPNS treatments during both the years. Phosphorus content in both corn seed and stover obtained from T_3 treated plot values 0.450% and T_3 and T_8 treated plot value 0.705% respectively. In average were found significantly higher over remaining treatments. However, minimum P_2O_5 content was in seed and stover observed under T_9 and T_1, respectively. Regarding P2O5 intake in seed and stover, T_3 showed significantly higher P_2O_5 intake (22.77 kg/

ha seed and 42.67 kg /ha in stover in 1st and 24.55 and 42.99 kg ha^{-1} in 2nd year) (Table 4) (Figure 4a,4b).

K_2O content and intake in corn

Differences in K_2O content and intake in corn seed and stover due to various IPNS treatments were found significant higher values of 0.590% and 1.800% K_2O in seed and stover, respectively on the basis of average data were associated with T_3 (Farm Yard Manure + Chemical fertilizer). Significantly higher K_2O intake in seed was found under T_4 which was significantly higher than rest of the treatments except T_3. Moreover, highest K_2O intake in stover was showed with T_3. The minimum value was obtained under T_9 (60.888 kg ha^{-1} in average values) (Table 5) (Figure 5a, 5b).

Results from Table 3, 4 & 5 reveals that N_2, P_2O_5 and K_2O content and their intake by corn seed & stover were maximum under integrated use of FYM + Chem. fertilizer (T_3) which was *at par* with treatment T_8 (*Azoto* + *Rhizobium* + PSB + FYM + Chem.) and T_4 (*Azoto* + *Chem.*). These treatments showed significant superiority over the other remaining treatments. This might be due to increased supply of nutrients directly through organic (FYM, PSB, *Azotobacter* & *Rhizobium*) and inorganic sources to the crop as well as indirectly through checking the loss of nutrients (N_2, P_2O_5 and K_2O) from soil solution which is turn resulted in better growth, higher biological yield as well as more nutrient concentration in treatment T_3 (Table 3). As microbial population increased, the amount of nitrogen fixed in soil and its availability to the plant also increased thereby, increasing the N intake. Nitrogen has synergistic effect on phosphorus intake by the corn plant probably due to increased cell activity by stimulation effect of nitrogen. *Azotobacter* increased the phosphorus intake probably due to the nutrient mobilization effect by which the soil phosphorus became more available to the plants. FYM not only supplied phosphorus but also solubilized with organic acids produced from the decomposition of organic matter and also provided favourable soil conditions to the micro-organism.

Table 1: Crop growth rate (CGR) of corn at different growth stages as influenced by integrated plant nutrient supply

Treatments	CGR (g / plant / day)											
	1st year				2nd year				Average			
	KH-T*	T-S*	S-M*	M-H*	KH-T	T-S	S-M	M-H	KH-T	T-S	S-M	M-H
T_1	2.92	2.14	2.55	0.69	3.05	2.09	2.56	0.60	2.99	2.12	2.56	0.65
T_2	3.23	1.07	2.12	0.38	3.68	1.51	2.84	0.31	3.46	1.29	2.48	0.35
T_3	4.08	2.63	1.85	0.85	4.13	2.83	1.77	0.72	4.11	2.73	1.81	0.79
T_4	2.95	2.44	2.92	0.34	3.12	2.30	2.95	0.28	3.04	2.37	2.94	0.31
T_5	2.69	2.09	2.07	0.54	2.84	1.97	3.00	0.15	2.77	2.03	2.54	0.35
T_6	2.78	2.01	2.83	0.64	3.01	1.79	3.05	0.52	2.90	1.90	2.94	0.58
T_7	3.34	2.21	2.59	0.44	3.00	2.77	2.92	0.18	3.17	2.49	2.76	0.31
T_8	3.78	2.45	2.18	0.28	3.80	2.66	2.14	0.16	3.79	2.56	2.16	0.22
T_9	2.13	1.78	3.42	0.69	2.35	1.76	3.19	0.66	2.24	1.77	3.31	0.68
S.Em.±	0.082	0.16	0.32	0.051	0.086	0.14	0.31	0.054	0.09	0.13	0.29	0.06
CD (0.05)	0.249	0.46	0.97	0.154	0.254	0.47	0.98	0.164	0.281	0.44	0.311	0.18

*Growth stages: KH- Knee high, T-Tassel, S-Silky. M-Milky, H- Harvest

Table 2: N_2 content and intake by seed and stover of corn as influenced by integrated plant nutrient supply

Treatments	N_2 Content (%)						N_2 Intake (kg ha^{-1})					
	Seed			Stover			Seed			Stover		
	1st year	2nd year	Average	1st year	2nd year	Average	1st year	2nd year	Average	1st year	2nd year	Average
T_1	1.31	1.32	1.32	0.75	0.74	0.75	45.64	50.87	48.26	31.48	34.40	32.94
T_2	1.38	1.40	1.39	0.76	0.77	0.77	53.49	56.42	54.95	35.31	37.20	36.25
T_3	1.50	1.52	1.51	0.97	0.98	0.98	77.61	81.14	79.37	58.30	60.19	59.24
T_4	1.40	1.41	1.41	0.84	0.86	0.85	62.78	60.97	61.87	44.91	44.75	44.83
T_5	1.33	1.33	1.33	0.70	0.72	0.71	42.87	51.06	46.96	27.15	33.24	30.19
T_6	1.34	1.34	1.34	0.72	0.73	0.73	47.15	53.00	50.08	30.55	34.42	32.48
T_7	1.36	1.39	1.38	0.83	0.84	0.84	53.12	57.28	55.20	38.45	40.67	39.56
T_8	1.42	1.45	1.44	0.89	0.89	0.89	64.11	65.57	64.84	44.14	46.84	45.49
T_9	1.29	1.30	1.30	0.68	0.68	0.68	40.17	45.64	42.91	25.67	29.16	27.41
S.Em.±	0.0098	0.0056	0.0056	0.0069	0.0075	0.0048	3.01	2.89	1.94	2.14	2.37	0.51
CD (0.05)	0.029	0.018	0.018	0.020	0.022	0.015	9.45	8.23	6.34	6.40	7.31	1.67

Table 3: P_2O_5 content and intake by seed and stover of corn as influenced by integrated plant nutrient supply

Treatments	P_2O_5 Content (%)						P_2O_5 Intake (kg ha^{-1})					
	Seed			Stover			Seed			Stover		
	1st year	2nd year	Average	1st year	2nd year	Average	1st year	2nd year	Average	1st year	2nd year	Average
T_1	0.36	0.37	0.35	0.400	0.410	0.405	12.54	14.26	13.40	16.79	19.06	17.92
T_2	0.40	0.39	0.39	0.410	0.400	0.405	15.50	15.72	15.61	19.05	19.32	19.19
T_3	0.44	0.46	0.45	0.710	0.700	0.705	22.77	24.55	23.66	42.67	42.99	42.83
T_4	0.37	0.36	0.36	0.560	0.580	0.570	16.59	15.57	16.08	29.94	30.18	30.06
T_5	0.30	0.31	0.30	0.500	0.500	0.500	11.67	11.90	11.78	19.40	23.08	21.24
T_6	0.32	0.32	0.32	0.510	0.500	0.505	11.26	12.66	11.96	21.64	23.58	22.61
T_7	0.38	0.39	0.38	0.600	0.610	0.605	14.84	16.07	15.46	27.80	29.54	28.67
T_8	0.41	0.42	0.41	0.700	0.710	0.705	18.51	18.99	18.75	34.72	37.37	36.04
T_9	0.31	0.32	0.31	0.500	0.520	0.510	9.65	11.24	10.44	18.88	22.30	20.59
S.Em.±	0.0072	0.0055	0.006	0.0052	0.0052	0.00081	1.12	1.21	0.18	2.11	2.21	0.77
CD (0.05)	0.021	0.016	0.019	0.015	0.015	0.0026	3.39	3.72	0.54	6.45	7.02	2.28

Table 4: K_2O content and intake by seed and stover of corn influenced by integrated plant nutrient supply

Treatments	K_2O Content (%)						K_2O Intake (kg ha^{-1})					
	Seed			Stover			Seed			Stover		
	1st year	2nd year	Average	1st year	2nd year	Average	1st year	2nd year	Average	1st year	2nd year	Average
T_1	0.54	0.54	0.54	1.55	1.55	1.55	18.81	20.81	19.81	65.05	72.04	68.55
T_2	0.56	0.57	0.57	1.57	1.57	1.57	21.71	22.97	22.34	72.94	75.85	74.39
T_3	0.59	0.58	0.59	1.80	1.80	1.80	30.53	30.96	30.74	108.16	110.56	109.37
T_4	0.56	0.50	0.53	1.74	1.74	1.74	25.11	21.62	23.37	93.02	90.53	91.78
T_5	0.50	0.52	0.51	1.54	1.54	1.54	16.12	19.96	18.04	59.74	71.09	65.41
T_6	0.52	0.55	0.54	1.58	1.58	1.58	18.30	21.75	20.03	67.04	74.50	70.77
T_7	0.55	0.55	0.55	1.60	1.60	1.60	21.48	22.67	22.07	74.13	77.47	75.80
T_8	0.58	0.57	0.58	1.77	1.77	1.77	26.19	25.78	25.98	87.79	93.16	90.47
T_9	0.50	0.50	0.50	1.51	1.51	1.51	15.57	17.56	16.56	57.00	64.75	60.88
S.Em.±	0.0092	0.0083	0.012	0.027	0.0055	0.00039	1.32	1.14	0.34	5.06	4.77	0.95
CD (0.05)	0.027	0.024	0.042	0.082	0.016	0.0012	3.97	3.49	1.07	15.58	14.30	3.93

Conclusion

Present investigation entitled **"**Influence of IPNS on Crop Growth Rate, N_2, P_2O_5, K_2O contents and their intake by seed and stover in corn" concluded that the crop growth rate (CGR) of corn was more at knee high to tasseling stage, which gradually declined towards the maturity during both the years of experimentation. Significant increase in CGR was recorded in treatments receiving organic, inorganic and bio-fertilizer sources of nutrients in combination. N_2, P_2O_5 and K_2O content and their intake in corn seed and stover obtained highest under treatment T_3 (FYM + Chem.) followed by T_8 (*Azotobactor* + *Rhizobium* + PSB + Chem.) and T_7 (*Azotobacter* + *Rhizobium* + PSB + Chem.) which were significantly superior to other treatments during both the years of investigation. The substitution of a part of inorganic fertilizer by organic sources and bio-fertilizers is the best approach to improve soil health for sustainable crop production. By adopting integrated plant nutrient supply we can get maximum yield with higher economic returns without causing soil pollution and spoiling soil health on long term basis.

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