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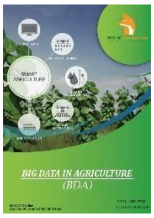

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RESEARCH ARTICLE

EVALUATION OF SPLIT APPLICATION OF POTASSIUM AND NITROGEN ON THE PERFORMANCE OF WINTER MAIZE HYBRID AT RAMPUR, CHITWAN

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ABSTRACT

Nutrient management practices significantly impact crop productivity and economics. A field experiment was conducted in the winter season of 2019-2020 in the sub-tropical climate of inner Terai, Nepal, using a split-plot design with three replications. The main plots included three potassium application methods: 0 kg K2O ha-1, 60 kg K2O ha-1 as basal, and 60 kg K2O ha-1 in two splits. The subplots involved five nitrogen application methods: 0 kg N ha-1, and 180 kg N ha-1 applied in different splits. Data on growth, yield attributes, yield, economics, nutrient use, uptake, and efficiency were collected. The results showed that grain and stover yield did not vary with different potassium application methods. The highest grain yield (6896.40 kg ha-1) was achieved with 90 kg N ha-1 at 15 DAS followed by 45 kg N ha-1 each at knee-high and tasseling stages. This yield was statistically similar to the method with 90 kg N ha-1 at basal and 45 kg N ha-1 each at knee-high and tasseling stages. Overall, yield attributes were similar across nitrogen treatments. The highest nutrient uptake was observed with the same nitrogen application method that produced the highest yield. Thus, applying 90 kg N ha-1 at 15 DAS followed by 45 kg N ha-1 at knee-high and tasseling stages is recommended for similar soils and climates as in Chitwan.

KEYWORDS

Productivity, Agricultural Economics, Nutrient uptake, Performance evaluation, Fertilizer application, Maize cultivation

1. INTRODUCTION

Maize is a versatile crop and it has been used for various domestic and industrial purposes. Maize is the second most cultivated cereal in Nepal and in the world. In Nepal maize is cultivated for grain and fodder, grain is mostly used for human consumption and feed for poultry and milking animals. Maize grain contains about 72% starch, 10% protein, 4.8% oil, 9.5% fiber and 1.7% ash (Chaudhary, 1983). Maize protein lacks amino acids tryptophan and lysine and it is considered the queen of cereal. The production of maize in 2018 was 2555847mt with the productivity of 2.678 mt ha^{-1} and cultivated in a 954158ha area. The production was 255726 mt more than the previous year and cultivated in 53870ha more area as compared to the previous year. The productivity of maize also improved as compared to the previous year (2.55 t ha^{-1} in 2017). Maize contributed about 25.52% of total cereal production in 2018 (MoALD, 2019).

Nitrogen (N) and potassium (K) are two macronutrients needed by plants in large amounts, and in most plants, they are the two nutrients needed in the highest quantities for optimum growth and development. Nitrogen is the most limiting element in crop production and its efficient use is very important for the economic production and sustainability of the cropping system. Nitrogenous fertilizer is a high-cost input for maize production and it is difficult to manage because efficient crop production and utilization are dependent on agronomic, genetic, biological, and environmental factors. The lower recovery percent of nitrogen in most of the annual crop is due to its losses by volatilization, leaching, and runoff (Fageria and Baligar, 2005).

The recovery efficiency of applied nitrogen depends upon the time of application and environmental conditions. Spring application of fertilizer has more efficiency than fall application because of less loss of applied nitrogen between the time of application and crop uptake (Randall and Sawyer, 2020). Efficient use of nitrogen is a very important factor for maximizing the yield and lowering the leaching of nitrate ions to groundwater in maize (Gehl, et al., 2005). Splitting of nitrogen improves the nitrogen use efficiency as compared to full basal application because it increases the nitrogen uptake during mid and late plant growth stage (Du et al., 2019). Balance and judicious knowledge on nitrogen supply, crop demand and the ecological condition improves the yield of cereal crops, minimize the cost of production, and maximizes the profit with maintaining a good ecosystem and less pollution to groundwater (Cassman et al., 2002).

The root of the upper surface of the soil (0-20 cm) absorbs almost twice nitrogen as compared to that of the root of the lower surface (70-100 cm) of soil. The early root developed in the plant can absorb more nitrogen so the application of nitrogenous fertilizer at that time has high nitrogen use efficiency (Liao et al., 2006). Nitrogen is a very mobile nutrient in soil system and it is very liable to lose by leaching and volatilization and applied nitrogen can be lost when plant takes time to strengthen the root system. Uptake of nitrogen is started when the root systems strengthen, and plant develops one or two leaves. So, it is better to apply the first dose of nitrogen of split application when the plant at V_2 stage and it can rapidly uptake the plant nutrient (Hammad et al., 2011).

Application of full dose of potassium is generally applied as basal by Nepalese farmers due to easiness in the application and low labor cost. But the potassium applied as basal may be lost by various mechanisms like leaching, surface runoff, etc.(Murrell et al., 2021). There is a scarcity of

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potassium at later stages of maize plants like knee high, tasseling stages which are the key stage for determining the yield of maize. Plants respond positively with the split application of potassium. Generally, 2-3 split application found beneficial, it is beneficial as compared to a single application of a full dose of potassium at the time of planting due to higher leaf area index, crop growth rate, chlorophyll content of leaf, potassium accumulation in grain, and higher potassium use efficiency (Kolar and Grewal, 1994).

2. MATERIALS AND METHODS

2.1 Description of the experimental site

2.1.1 Location

The research was conducted in the Horticulture farm of Agriculture and forestry university Rampur, Chitwan from September 2019 to April 2020. Geographically it is situated in the central Terai of Nepal in Bagmati Province. It is located 9.8 km South-West of Bharatpur, headquarters of Chitwan district. The experimental site is situated at 27^0 37'' North latitude and 84^0 25'' East longitudes with an elevation of 256 meters above mean sea level.

2.2 Experimental details

Table 1: Experimental details of the field experiment at AFU, Rampur, Chitwan, 2019/20

S.N.	Particulars	Details
1	Experimental design	Split plot design
2	Main plot factor	3
3	Subplot factor	5
4	Total no. of treatment	15
5	No. of replication	3
6	Individual plot size	4.8 m * 4.5 m
7	No. of rows	8
8	Net plot size	10.8 m^2
9	Spacing	60 cm * 25 cm
10	Variety used	Rampur hybrid 10
11	Planting date	Oct 2019
12	Harvesting date	April 2020

2.2.1 Treatment details

Main plot factor (M): Potassium application times

a. K0 = 0 kg ha^{-1} K_2O

b. K1 = 60 kg ha^{-1} K_2O as basal

c. K2 = 30 kg ha^{-1} K_2O as basal + 30 kg ha^{-1} K_2O as top dressing at knee high stage

Sub plot factor (S): Nitrogen application times

a. N0 = 0 kg ha^{-1} N

b. N1 = 1/2 N at basal + 1/4 N at knee high stage + 1/4 N at tasseling stage

c. N2 = 1/2 N at 15 DAP + 1/4 N at knee high stage + 1/4 N at tasseling stage

d. N3 = 1/3 N at 15 DAP +1/3 N at knee high stage + 1/3 N at tasseling stage

e. N4 = 1/4 N at 15 DAP +1/2 N at knee high stage + 1/4 N at tasseling stage

2.2.1 Field layout

The experimental field was laid out in a split-plot design with three replications and has 15 treatment combinations. The split application of potassium was the main plot factor and the starter dose was the subplot factor. Each replication was separated by 1m distance and each plot by 0.5 m. Row to row distance was 60 cm and plant to plant distance was 25 cm.

2.2.2 Variety

Rampur hybrid 10 was used in the research which is a hybrid variety and registered in 2074 BS. The maturity period of Rampur hybrid 10 is 120-160 days and is recommended for terai, inner terai up to 700 masl for the winter season. Yield potential of Rampur hybrid 10 is 8.5 t ha^{-1} and its height can be up to 250 cm.

3. RESULTS

3.1 Effect of potassium and nitrogen application method on phenological stages of maize

Plant phenology studies the period between like events, dissimilar events, or the duration of the process. Like events include the time intervals between main stem leaves or branch leaves on the plant. Unlike events include the intervals between plant germination and formation of a bud, flower, or mature fruit (Reddy et al., 1997).

Table 2: Phenological stages of winter maize hybrid as affected by split application of potassium and nitrogen at Rampur Chitwan, 2019/20

Treatments	Phenological stages (DAS)					
	Emergence	Tasseling	Silking	TSI	PM	SFD
Doses of potassium (kg ha^{-1})						
0	6.33	94.33	100.86	6.73	160.53	59.66
60	6.60	93.40	100.46	7.06	160.53	60.06
30 + 30	6.53	93.00	100.46	7.46	160.20	59.73
SEm (±)	0.08	0.39	0.13	0.21	0.11	0.12
LSD (=0.05)	ns	ns	ns	ns	ns	ns
Probability	0.07	0.58	0.72	0.49	0.58	0.68
CV, %	3.6	3.6	2.4	22	0.6	5.5
Doses of nitrogen (kg ha^{-1})						
0	6.55	95.88^a	103.66^a	7.77^a	155.88^b	52.22^b
$90_{(0\ DAS)}$ + 45 + 45	6.44	91.88^c	99.66^b	7.77a	162.33^a	62.66^a
$90_{(15\ DAS)}$ + 45 + 45	6.55	92.77^{bc}	100.11^b	7.33^{ab}	162.11^a	62.00^a
$60_{(15\ DAS)}$ + 60 + 60	6.44	94.33^{ab}	99.88^b	5.88^c	160.88^a	61.00^a
$45_{(15\ DAS)}$ + 90 + 45	6.44	93.00^{bc}	99.66^b	6.66^{bc}	160.88^a	61.22^a
SEm (±)	0.02	0.69	0.77	0.36	1.17	1.92
LSD (=0.05)	Ns	2.19	1.99	0.99	1.41	2.34
Probability	0.98	<0.01	<0.01	<0.01	<0.01	<0.01
CV, %	9.5	2.4	2	14.4	0.9	4
Grand mean	6.48	93.57	100.6	7.08	160.42	59.82

Note: TSI, tasseling to silking interval; PM, physiological maturity SFD, Seed fill duration; LSD, least significant difference; ns, non-significant. Treatments means followed by the common letter(s) within the column are not significantly different among each other based on DMRT at a 5% level of significance.

3.1.1 Emergence

The maize seeds planted in the cold moist soil absorb water through the seed coat and begin to swell. Chemical changes activate the growth in the embryo axis and if conditions continue to be favorable, the radical elongates and emerges from the seed coat within 2 or 3 days. Shortly thereafter, the plumule also begins to elongate and additional leaves begin to form inside the part of the developing seedling (Tian et al., 2014). On an average emergence of seed found at the 6.48 days after sowing.

Germination was not significantly affected by the potassium and nitrogen application method. In all plot seed emerged between the 5th and 7th days of sowing.

3.1.2 Days to tasseling

There were non-significant differences of days to tasseling but it was relatively earlier in 30 kg K_2O –basal + 30 kg K_2O – top dressing (93.00 days) as compared to 60 kg K_2O – basal application (93.40 days) and control (94.33 days). Days to tasseling was significantly affected by the nitrogen application method. It is significantly delayed in control (95.88 days) which was statistically at par with N application of 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (94.33 days). Tasseling in N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling was found to be significantly earlier (91.88 days). N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (92.77 days) and 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (93 days) showed the intermediate days for tasseling

3.1.3 Days to silking

In the case of days to silking, the difference due to the potassium application method was non-significant. It was relatively delayed in control (100.86 days) as compared to 60 kg K_2O – basal application (100.46 days) and 30 kg K_2O –basal + 30 kg K_2O – top dressing (100.46 days). Days to silking was significantly affected by the nitrogen application method. It was significantly higher in control (103.66 days) as compared to other nitrogen application methods. N application of 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (99.6 days) and 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (99.6 days) produced significantly earlier silking.

3.1.4 Tasseling Silking Interval (TSI)

TSI was not significantly affected by the potassium application method and it was recorded relatively higher in 30 kg K_2O –basal + 30 kg K_2O – top dressing (7.46 days) as compared to 60 kg K_2O – basal application (7.06 days) and control (6.73 days). Significantly lower TSI was observed in the N application of 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (5.88 days) and it was statistically at par with N application of 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (6.66 days). TSI was significantly higher in the N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (7.77 days) and control (7.77 days).

3.1.5 Physiological Maturity (PM)

Days to physiological maturity was not significantly affected by the potassium application method. Days to physiological maturity was recorded lowest in potassium application of 30 kg K_2O –basal + 30 kg K_2O – top dressing (160.20 days). Significant effect of nitrogen application method was observed in days to maturity. Days to physiological maturity was found significantly higher in N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (162.33 days) whereas significantly lower days to physiological maturity was found in control (155.88 days).

3.1.6 Seed fill duration

Overall seed filling duration of the experiment was 59.82 days. Seed filling duration was not significantly affected by the potassium application method. Comparatively higher seed filling duration was observed in the potassium application method of 60 kg K_2O – basal application (60.06 days) followed by 30 kg K_2O –basal + 30 kg K_2O – top dressing (59.73 days) and control (59.66). However, the effect of the nitrogen application method in seed filling duration was significant. Significantly higher seed filling duration was recorded in the nitrogen application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (62.66 days). Seed filling duration was significantly lower in the control (52.22 days). Intermediate seed filling duration was observed in the N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (62.00 days), 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (61.00 days), and 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (61.22 days).

3.2 Biometrical observations of maize

3.2.1 Plant height

Plant height is an important attribute that determines the growth of maize plants. It reflects the efficiency of the plant for photosynthesis and vegetative growth character of crop plants in response to various applied inputs. The analyzed data (Table 3) revealed that on average plant height increased up to 160.72 cm at 105 DAS. Plant height was found non-significant due to the effect of potassium application methods at all of the growth stages. Initially plant height was relatively higher in the 60 kg K_2O – basal application (30 DAS, 45 DAS, and 60 DAS). At later growth stage 75 DAS, 90 DAS, and 105 DAS plant height were recorded comparatively higher in 30 kg K_2O –basal + 30 kg K_2O – top dressing. At 105 DAS, the relatively highest plant height was observed in 30 kg K_2O –basal + 30 kg K_2O – top dressing (161.31 cm) whereas plant height was lowest in control (160.09 cm).

At all growth stages, plant height was found to be significantly affected by the nitrogen application method. At 30 DAS, plant height was significantly higher in N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (47.43 cm), and significantly lower plant height was found in control (36.13 cm). At 45 DAS, 60 DAS, 75 DAS, and 90 DAS plant height was recorded significantly higher in N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (77.77 cm, 103.71 cm, 120.30 cm, and 145.17) but significantly lower plant height was observed in control (50.66 cm, 69.13 cm, 82.06 cm, and 108.06 cm). At 105 DAS, significantly higher plant height was recorded in N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (173.82 cm) as compared to 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (159.22 cm),1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (160.86 cm) and control (142.35 cm) but it was statistically at par with N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (167.35 cm).

Table 3: Plant height of winter maize hybrid as affected by split application of potassium and nitrogen at Rampur Chitwan, 2019/20

Treatments	Plant height (cm)					
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS
Doses of potassium (kg ha^{-1})						
0	41.50	64.80	87.40	103.94	130.52	160.09
60	41.78	67.80	89.91	105.60	131.17	160.73
30 + 30	40.85	66.31	86.78	105.92	131.80	161.31
SEm(±)	0.27	0.86	0.94	0.61	0.37	0.36
LSD (=0.05)	ns	ns	ns	ns	ns	ns
Probability	0.86	0.57	0.76	0.84	0.98	0.97
CV, %	11.5	11	13.4	9.3	14.7	8.9
Doses of nitrogen (kg ha^{-1})						
0	36.13^{d}	50.66^{c}	69.13^{c}	82.06^{c}	108.06^{c}	142.35^{c}
90$_{(0\ DAS)}$ + 45 + 45	47.43^{a}	77.77^{a}	103.71^{a}	120.30^{a}	145.17^{a}	173.82^{a}
90$_{(15\ DAS)}$ + 45 + 45	44.33^{b}	73.80^{a}	98.11^{a}	118.84^{a}	140.33^{ab}	167.35^{ab}
60$_{(15\ DAS)}$ + 60 + 60	39.28^{c}	63.32^{b}	85.00^{b}	104.01^{b}	132.73^{ab}	160.86^{b}
45$_{(15\ DAS)}$ + 90 + 45	39.71^{c}	65.96^{b}	83.86^{b}	100.55^{b}	129.52^{b}	159.22^{b}
SEm(±)	2.00	4.69	6.04	6.97	6.39	5.26
LSD (=0.05)	2.53	6.21	8.36	7.62	12.50	8.24
Probability	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CV, %	6.3	9.6	9.8	7.5	9.8	5.3
Grand mean	41.38	66.30	87.96	105.15	131.16	160.72

Note: LSD, least significant difference; ns, non-significant. Treatments means followed by common letter(s) within column are not significantly different among each other based on DMRT at 5% level of significance

3.2.2 Number of leaves plant^{-1}

The analyzed data (Table 4) revealed that on average, the number of leaves per plant increased from 30 DAS to 90 DAS, and thereafter it remained constant due to senescence, drying of old leaves, and plant reached at maximum leaf stage. The highest number of leaves per plant was recorded at 90 DAS (12.62), 105 DAS (12.62) and the lowest at 30 DAS (6.50). The effect of the potassium application method on a number of leaves plant^{-1} was found to be significant at 30 DAS and 75 DAS but a non-significant difference was observed at other growth stages. At 30 DAS significantly, higher number of leaves plant^{-1} was recorded in the 30 kg K_2O –basal + 30 kg K_2O – top dressing (6.64) as compared to 60 kg K_2O – basal application (6.45) and control (6.41). At 75 DAS significantly, higher number of leaves plant^{-1} was found in control (11.78) as compared to 30 kg K_2O 0 –basal + 30 kg K_2O – top dressing (11.49) and it was statistically at par with 60 kg K_2O – basal application (11.74). At 45 DAS and 60 DAS, number of leaves plant^{-1} was non-significantly higher in 60 kg K_2O – basal application (8.41, 10.09). At 90 DAS and 105 DAS, the comparatively higher number of leaves plant^{-1} was observed in control (12.76, 12.78) and lowest in 60 kg K_2O – basal application (12.50, 12.56).

At all growth stages of maize, the number of leaves plant^{-1} was significantly affected by the nitrogen application method. At 30 DAS and 45 DAS, the number of leaves plant^{-1} was recorded significantly higher in N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (7.24 and 9.06), and the lowest number of leaves plant^{-1} were found in control (5.75 and 6.86). At 60 DAS, a significantly higher number of leaves plant^{-1} was recorded in N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (10.86) and it was statistically at par with N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (10.80). At 75 DAS, the number of leaves plant^{-1} was recorded significantly higher in N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (12.24), and the lowest number of leaves plant^{-1} was found in control (10.53). But at 90 DAS, the significantly higher number of leaves plant^{-1} found in the N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (13.40) as compared to 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (12.55), control (11.17) and it was statistically at par with 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (13.35) and 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (12.64). At 105 DAS, the effect of nitrogen application method on the number of leaves plant^{-1} was significantly higher in 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (13.51) as compared to 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (12.48), control (10.88) and it was statistically at par with 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (13.46) and 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (12.77).

Table 4: Number of leaves plant^{-1} of winter maize hybrid as affected by split application of potassium and nitrogen at Rampur Chitwan, 2019/20

Treatments	Number of leaves plant^{-1}					
	30 DAS	**45 DAS**	**60 DAS**	**75 DAS**	**90 DAS**	**105 DAS**
Doses of potassium (kg ha^{-1})						
0	6.41^{b}	8.14	9.94	11.78^{a}	12.76	12.68
60	6.45^{b}	8.41	10.09	11.74^{a}	12.50	12.56
30 + 30	6.64^{a}	8.09	10.06	11.49^{b}	12.61	12.64
SEm(±)	0.06	0.54	0.04	0.09	0.07	0.03
LSD (=0.05)	0.16	ns	ns	0.17	ns	ns
Probability	0.04	0.32	0.75	0.018	0.60	0.77
CV, %	2.6	6.6	5.4	1.5	5.2	3.6
Doses of nitrogen (kg ha^{-1})						
0	5.75^{c}	6.86^{c}	8.64^{c}	10.53^{c}	11.17^{c}	10.88^{c}
90$_{(0\ DAS)}$ + 45 + 45	7.24^{a}	9.06^{a}	10.80^{a}	12.22^{a}	13.40^{a}	13.46^{a}
90$_{(15\ DAS)}$ + 45 + 45	6.93^{a}	8.88^{a}	10.86^{a}	12.24^{a}	13.35^{a}	13.51^{a}
60$_{(15\ DAS)}$ + 60 + 60	6.26^{b}	8.02^{b}	9.97^{b}	11.77^{ab}	12.55^{b}	12.77^{ab}
45$_{(15\ DAS)}$ + 90 + 45	6.31^{b}	8.24^{b}	9.88^{b}	11.60^{b}	12.64^{ab}	12.48^{b}
SEm(±)	0.26	4.64	0.40	0.31	0.40	0.47
LSD (=0.05)	0.46	0.46	0.57	0.46	0.73	0.91
Probability	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CV, %	7.4	5.8	5.9	4.1	6	7.4
Grand mean	6.50	8.21	10.03	11.67	12.62	12.62

Note: LSD, least significant difference; ns, non-significant. Treatments means followed by common letter(s) within column are not significantly different among each other based on DMRT at 5% level of significance

3.2.3 Leaf area index (LAI)

As the leaves grow, their ability to photosynthesize increases for a time and then often even before maturity begins slowly to decrease. Leaves produce about 90% of the total biomass of plants. The leaf area index (LAI) is an important parameter to evaluate the radiation and precipitation interception, energy conversion, and water balance in the plant (Trimble, 2019). In this experiment, the grand mean value of LAI (Table 5) indicates that it increased very rapidly from 30 DAS to 75 DAS and then increased at a very slow rate up to 105 DAS due to drying of old leaves and plant attained maximum leaf stage. On average, the lowest LAI value was observed at 30 DAS and the maximum LAI value at 105 DAS. The LAI recorded at all of the growth stages of the plant was non-significant with the effect of the potassium application method. At 30 DAS and 45 DAS, higher LAI was found in 30 kg K_2O –basal + 30 kg K_2O – top dressing (0.30 and 0.99) as compared to 60 kg K_2O – basal application (0.29 and 0.94) and control (0.29 and 0.94). At 60 DAS insignificantly, higher LAI was recorded in 60 kg K_2O – basal application (1.34). But at the 75 DAS, 90 DAS, and 105 DAS relatively higher LAI was observed in the 30 kg K_2O –basal + 30 kg K_2O – top dressing (2.79, 2.80, and 3.05) as compared to 60 kg K_2O – basal application (2.60, 2.78 and 2.97) and control (2.57, 2.67 and 2.88).

Table 5: Leaf area index (LAI) of winter maize hybrid as affected by split application of potassium and nitrogen at Rampur Chitwan, 2019/20

Treatments	Leaf Area Index (LAI)					
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS
Doses of potassium (kg ha^{-1})						
0	0.29	0.94	1.26	2.57	2.67	2.88
60	0.29	0.94	1.34	2.60	2.78	2.97
30 + 30	0.30	0.99	1.21	2.79	2.80	3.05
SEm(±)	0.0034	0.016	0.037	0.066	0.04	0.04
LSD (=0.05)	ns	ns	ns	ns	ns	ns
Probability	0.83	0.86	0.62	0.77	0.90	0.75
CV, %	18	29.4	26.8	32.5	30.4	20.5
Doses of nitrogen (kg ha^{-1})						
0	0.26^{b}	0.48^{c}	0.66^{c}	1.73^{d}	1.88^{d}	2.05^{c}
90$_{(0\ DAS)}$ + 45 + 45	0.37^{a}	1.37^{a}	1.64^{a}	3.41^{a}	3.49^{a}	3.70^{a}
90$_{(15\ DAS)}$ + 45 + 45	0.30^{b}	1.12^{ab}	1.61^{a}	2.99^{ab}	3.22^{ab}	3.55^{a}
60$_{(15\ DAS)}$ + 60 + 60	0.28^{b}	1.00^{b}	1.28^{b}	2.63^{bc}	2.71^{bc}	2.87^{b}
45$_{(15\ DAS)}$ + 90 + 45	0.24^{b}	0.82^{b}	1.16^{b}	2.50^{c}	2.44^{c}	2.64^{b}
SEm(±)	0.021	0.14	0.178	0.28	0.28	0.30
LSD (=0.05)	0.066	0.32	0.32	0.45	0.53	0.52
Probability	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CV, %	23	35.2	25.8	17.4	20	18.2
Grand mean	0.29	0.96	1.27	2.65	2.75	2.96

Note: LSD, least significant difference; ns, non-significant. Treatments means followed by common letter(s) within column are not significantly different among each other based on DMRT at 5% level of significance

Further, at all growth stages of the plant LAI was significantly different from nitrogen application method. At 30 DAS, 45 DAS, 60 DAS, 75 DAS, 90 DAS and 105 DAS, significantly higher LAI was recorded in N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (0.37, 1.37, 1.64, 3.41, 3.49, and 3.70) which was statistically at par with N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (0.30, 1.12, 1.61, 2.99, 3.22 and 3.55). Significantly lower LAI was observed in the control.

3.2.3 SPAD value of green leaves

At all growth stages, the effect of the potassium application method on SPAD value was non-significant. At 55 DAS and 85 DAS, SPAD value was found comparatively higher in 30 kg K_2O –basal + 30 kg K_2O – top dressing (43.66 and 42.27) followed by 60 kg K_2O – basal application (43.00 and 42.15) and control (42.12 and 42.10). Further, SPAD value was found to be significantly affected by the nitrogen application methods in all growth stages of the plant. This simply represents the effect of nitrogen on the greenness and chlorophyll content of the plant. At 55 DAS, a significantly higher SPAD value was recorded in the application of 1/2 N at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (46.34) which was statistically at par with 1/2 N at basal + 1/4 at Knee high + 1/4 at Tasseling (44.55) and 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (44.20) whereas significantly lower SPAD value was observed in control (36.91). Intermediate SPAD value was observed in the application of 1/4 N at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (42.62). Moreover, at 85 DAS, the SPAD value was significantly higher in the application of 1/3 N at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (43.98) as compared to control (37.87) but it was statistically at par with other nitrogen application methods.

Table 6: SPAD value of winter maize hybrid as affected by split application of potassium and nitrogen at Rampur Chitwan, 2019/20

Treatments	SPAD value	
	55 DAS	85 DAS
Doses of potassium (kg ha^{-1})		
0	42.12	42.10
60	43.00	42.15
30 + 30	43.66	42.27
SEm(±)	0.44	0.04
LSD (=0.05)	ns	ns
Probability	0.48	0.70
CV, %	7.4	1.3
Doses of nitrogen (kg ha^{-1})		
0	36.91^{c}	37.87^{b}
90$_{(0\ DAS)}$ + 45 + 45	44.55^{ab}	42.17^{a}
90$_{(15\ DAS)}$ + 45 + 45	46.34^{a}	43.22^{a}
60$_{(15\ DAS)}$ + 60 + 60	44.20^{ab}	43.98^{a}
45$_{(15\ DAS)}$ + 90 + 45	42.62^{b}	43.62^{a}
SEm(±)	1.61	1.11
LSD (=0.05)	2.57	2.12
Probability	<0.01	<0.01
CV, %	6.2	5.2
Grand mean	42.92	42.17

Note: SPAD, soil plant analysis development; LSD, least significant difference; ns, non-significant. Treatments means followed by common letter(s) within column are not significantly different among each other based on DMRT at 5% level of significance

3.2.4 Above-ground biomass of maize plant

The above ground biomass is an important indicator for the yield of the plant. Dry matter production depends upon the rate of photosynthesis, nutrient absorption, and other vital activities. The distribution of the remaining amount of photosynthates to different plant parts determines the economic yield of the plant (Arnon, 1972). Dry matter production in maize plants was ranged from 14.53 g m^{-2} (30 DAS) to 1565.33 g m^{-2} (120 DAS). Dry matter produced in all growth stages of maize was non-significant with the potassium application method. At 30 DAS relatively, higher dry matter was produced in 30 kg K_2O –basal + 30 kg K_2O – top dressing (15.04 g m^{-2}) than that of 60 kg K_2O – basal application (14.87 g m^{-2}) and control (13.70 g m^{-2}). At 60 DAS and 90 DAS higher dry matter was recorded in the 60 kg K_2O – basal application (144.30 and 394.36 g m^{-2}) as compared to other potassium application methods. At 120 DAS, comparatively higher dry matter production was higher in the 30 kg K_2O –basal + 30 kg K_2O – top dressing (1662.57 g m^{-2}) followed by 60 kg K_2O – basal application (1641.38 g m^{-2}). The lowest dry matter production was found in control (1393.04 g m^{-2}).

Table 7: Above ground biomass of winter maize hybrid as affected by split application of potassium and nitrogen at Rampur Chitwan, 2019/20

Treatments	Above ground biomass (g m^{-2})			
	30 DAS	60 DAS	90 DAS	120 DAS
Doses of potassium (kg ha^{-1})				
0	13.70	135.24	376.09	1393.04
60	14.87	144.30	394.36	1641.38
30 + 30	15.04	141.58	391.25	1662.57
SEm(±)	0.42	2.68	5.64	86.86
LSD (=0.05)	ns	ns	ns	ns
Probability	0.62	0.77	0.85	0.30
CV, %	26.7	24.5	24.2	29.3
Doses of nitrogen (kg ha^{-1})				
0	13.33^{bc}	74.68^{c}	266.08^{b}	753.34^{d}
$90_{(0\ DAS)}$ + 45 + 45	18.50^{a}	188.25^{a}	495.38^{a}	2029.55^{a}
$90_{(15\ DAS)}$ + 45 + 45	14.98^{b}	175.12^{a}	459.35^{a}	1932.74^{ab}
$60_{(15\ DAS)}$ + 60 + 60	13.13^{bc}	135.39^{b}	385.16^{b}	1684.46^{bc}
$45_{(15\ DAS)}$ + 90 + 45	11.62^{c}	128.44^{b}	330.20^{b}	1426.55^{c}
SEm(±)	1.37	19.97	41.73	228.39
LSD (=0.05)	2.77	34.47	57.10	282.00
Probability	<0.01	<0.01	<0.01	<0.01
CV, %	19.6	25.2	15.2	18.5
Grand mean	14.53	140.38	387.23	1565.33

Note: LSD, least significant difference; ns, non-significant. Treatments means followed by common letter(s) within column are not significantly different among each other based on DMRT at 5% level of significance

Further, the dry matter accumulated in the maize plant was significantly affected by the nitrogen application method. At all growth stages, the accumulation of dry matter in the plant was higher with the application of 1/2 N basal + 1/4 at Knee high + 1/4 at Tasseling. At 30 DAS, significantly higher dry matter accumulated in the 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (18.50 g m^{-2}) whereas significantly lower dry matter production was recorded in control (11.44 g m^{-2}). Intermediate dry matter accumulation was observed in the N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (14.98 g m^{-2}), 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (13.13 g m^{-2}), and 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (11.07 g m^{-2}). Similarly at 60 DAS, 90 DAS, and 120 DAS, the significantly highest dry matter accumulation was observed in the N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (188.25, 495.38, and 2029.55 g m^{-2}) which was statistically at par with 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (175.12, 459.35 and 1932.74 g m^{-2}) whereas significantly lower value was observed in the control (74.68, 266.08 and 753.34 g m^{-2}).

3.3 Yield attributing characters

3.3.1 Plant population ha^{-1}

Plant population ha^{-1} was not significantly affected by the Potassium application method. It was recorded relatively high in 30 kg K_2O –basal + 30 kg K_2O – top dressing (62983.40) as compared to 60 kg K_2O – basal application (61079.69) and control (61771.05). Similarly, the effect of the nitrogen application method was not significant for plant population ha^{-1}. Although higher plant population ha^{-1} was recorded in control (62390.95) as compared to 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (61782.20), 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (61831.28), 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (61877.37) and 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (61841.77).

3.3.2 Number of cobs ha^{-1}

The potassium application method had no significant effect on the number of cobs ha^{-1}. A comparatively higher number of cob ha^{-1} was recorded in the 30 kg K_2O –basal + 30 kg K_2O – top dressing (69141.23) as compared to 60 kg K_2O – basal application (67163.98) and control (66073.53). The number of cob ha^{-1} of maize was significantly affected by the nitrogen application method. Application of 1/2 N at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (70327.16) produced the significantly higher number of cob ha^{-1} as compared to control (62240.25) but it was statistically at par with other nitrogen application method.

3.3.3 Number of kernel rows cob^{-1}

The number of kernel rows cob^{-1} is the main character indicating the economic yield of maize. The data of Table 10 shows that the number of kernel rows cob^{-1} recorded was not significantly affected by the potassium application method. Higher kernel rows cob^{-1} was found in the potassium application method of 30 kg K_2O –basal + 30 kg K_2O – top dressing (12.77) as compared to 60 kg K_2O – basal application (12.72) and control (12.65).

But, the number of kernel rows cob^{-1} was significantly affected by the nitrogen application method. Significantly higher kernel rows cob^{-1} were observed in the N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (13.13) as compared to N application of 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (12.52) and control (12.16) but it was statistically at par with 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (12.97) and 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (12.78).

3.3.4 Number of kernels row^{-1}

The effect of the potassium application method on kernel row^{-1} was non-significant. A relatively higher number of kernel row^{-1} was found in the potassium application of 30 kg K_2O –basal + 30 kg K_2O – top dressing

(21.58) followed by 60 kg K_2O – basal application (21.40) and control (20.47).

But, the number of kernel row^{-1} was significantly affected by the nitrogen application method. A significantly higher number of kernel row^{-1} was recorded in the N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (22.47)) and it was statistically at par with the application of 1/2Nat basal + 1/4 at Knee high + 1/4 at Tasseling (21.78), 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (22.21) and 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (22.46). A significantly lower number of kernel row^{-1} was observed in control (16.82).

3.3.5 Number of kernels cob^{-1}

The effect of the potassium application method on number of grains cob^{-1} was non-significant. Relatively higher kernels cob^{-1} was observed in the potassium application method of 30 kg K_2O –basal + 30 kg K_2O – top dressing (276.97) followed by 60 kg K_2O – basal application (272.64) and control (259.77).

The kernels cob^{-1} of maize plant was significantly affected by the nitrogen application method. Statistically similar kernels cob^{-1} was recorded in the nitrogen application methods of 1/2 N – basal + 1/4 at Knee high + 1/4 at Tasseling (282.96), 1/2 N at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (295.10), 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (283.96) and 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (281.25) which were significantly higher than control (205.69)

3.3.6 Thousand kernel weights

Mean kernel weight is an important yield contributing factor. Thousand kernel weight was not significantly affected by the potassium application method. Higher thousand kernel weight was recorded in the potassium application of 30 kg K_2O –basal + 30 kg K_2O – top dressing (349.25 g) followed by 60 kg K_2O – basal application (347.00 g) and control (341.75 g).

Thousand kernel weight was found to be significantly different for the nitrogen application method. Significantly higher thousand kernel weight was observed in the N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (365.50 g) as compared to control (312.90) but it was statistically at par with the application of 1/2 N at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (351.17 g), 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (360.66 g) and 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (339.77 g).

3.3.7 Cob length

On average cob length was measured to be 14.27 cm. Cob length was not significantly affected by the potassium application method. Relatively higher cob length was recorded in the potassium application method of 30 kg K_2O –basal + 30 kg K_2O – top dressing (14.57 cm) followed by 60 kg K_2O – basal application (14.39 cm) and control (13.84 cm).

The nitrogen application method significantly affected the cob length in maize. Significantly higher cob length was observed in the application of 1/2 N at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (15.01 cm) which was statistically similar with the application of 1/2 N at basal + 1/4 at Knee high + 1/4 at Tasseling (14.73 cm), 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (14.91 cm) and 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (14.78 cm). Control (11.90 cm) produced significantly lower cob length as compared to other nitrogen application methods.

Table 8: Yield attributing characters of winter maize hybrid as affected by split application of potassium and nitrogen at Rampur Chitwan, 2019/20

Treatments	Plants ('000 ha^{-1})	No. of cob ('000 ha^{-1})	No. of kernel rows cob^{-1}	No. of Kernel row^{-1}	Kernel cob^{-1}	Thousand kernels weight (g)
Doses of potassium (kg ha^{-1})						
0	61.77	66.07	12.65	20.47	259.77	341.75
60	61.07	67.16	12.72	21.40	272.64	347.00
30 + 30	62.98	69.14	12.77	21.58	276.97	349.25
SEm(±)	556.36	897.81	0.034	0.34	5.16	2.22
LSD (=0.05)	ns	ns	ns	ns	ns	ns
Probability	0.55	0.20	0.566	0.14	0.053	0.77
CV, %	7.3	5.8	2.3	6.1	5%	8.3
Doses of nitrogen (kg ha^{-1})						
0	62.39	62.24^{b}	12.16^{c}	16.82^{b}	205.69^{b}	312.90^{b}
90$_{(0\ DAS)}$ + 45 + 45	61.78	69.80^{a}	12.97^{ab}	21.78^{a}	282.96^{a}	365.50^{a}
90$_{(15\ DAS)}$ + 45 + 45	61.83	70.32^{a}	13.13^{a}	22.47^{a}	295.10^{a}	351.17^{a}
60$_{(15\ DAS)}$ + 60 + 60	61.87	68.31^{a}	12.78^{ab}	22.21^{a}	283.96^{a}	360.66^{a}
45$_{(15\ DAS)}$ + 90 + 45	61.84	66.61^{ab}	12.52^{bc}	22.46^{a}	281.25^{a}	339.77^{ab}
SEm(±)	112.59	1456.33	0.172	1.08	16.20	9.37
LSD (=0.05)	ns	5569.88	0.451	1.49	22.82	28.88
Probability	0.99	0.04	<0.01	<0.01	<0.01	<0.01
CV, %	5.4	8.5	3.6	7.3	8.7	8.6
Grand mean	61.94	67.45	12.71	21.15	269.79	346.00

Note: LSD, least significant difference; ns, non-significant. Treatments means followed by common letter(s) within column are not significantly different among each other based on DMRT at 5% level of significance

3.3.8 Cob diameter

Cob diameter was not significantly affected by the potassium application method. A relatively larger cob diameter was observed in the potassium application of 30 kg K_2O –basal + 30 kg K_2O – top dressing (4.26 cm) and the lowest cob diameter was observed in the 60 kg K_2O – basal application (4.22 cm).

The effect of the nitrogen application method was significant for cob diameter. Significantly higher cob diameter was recorded in the application of 1/3 N at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (4.35 cm) as compared to control (3.96 cm) and it was statistically similar with other nitrogen application methods.

3.3.9 Sterility (%) of cob

On average there was 13.06% sterility in the cob. The sterility of cob was not significantly affected by the potassium application method. Sterility was relatively higher in control (13.23) followed by 60 kg K_2O – basal application (13.22) and 30 kg K_2O –basal + 30 kg K_2O – top dressing (12.72).

Sterility was significantly affected by the nitrogen application method. Relatively higher sterility was observed in the control (20.64) as compared to other nitrogen application methods. Lowest sterility was observed in the application of 1/3 N at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (10.78).

3.3.10 Shelling percentage (%)

Non-significance difference of shelling percentage was observed with the potassium application method. Relatively higher shelling percentage was recorded in the 30 kg K_2O –basal + 30 kg K_2O – top dressing (82.84) followed by 60 kg K_2O – basal application (81.97) and control (81.44).

Similarly, the shelling percentage was not significantly affected by the nitrogen application method. Higher shelling percentage was observed in the application of 1/4 N at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (82.88) and lowest in 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (81.45).

3.3.11 Barrenness (%)

Barrenness was not significantly affected by the dose of potassium. The lowest barrenness was recorded in the control (4.64) as compared to 60 kg K_2O – basal application (6.95) and 30 kg K_2O –basal + 30 kg K_2O – top dressing (6.07). The barrenness of maize was significantly affected by the nitrogen application method. Significantly higher barrenness was recorded in the control (11.72) as compared to other nitrogen application method.

Table 9: Yield attributing characters of winter maize hybrid as affected by split application of potassium and nitrogen at Rampur Chitwan, 2019/20

Treatments	Cob length (cm)	Cob diameter (cm)	Sterility of cob (%)	Shelling percentage	Barrenness (%)
Doses of potassium (kg ha^{-1})					
0	13.84	4.23	13.23	81.44	4.64
60	14.39	4.22	13.22	81.97	6.95
30 + 30	14.57	4.26	12.72	82.84	6.07
SEm(±)	0.217	0.01	0.16	0.40	0.67
LSD (=0.05)	ns	ns	ns	ns	ns
Probability	0.09	0.49	0.79	0.09	0.20
CV, %	4.9	2.3	17.7	1.6	49.1
Doses of nitrogen (kg ha^{-1})					
0	11.90^b	3.92^b	20.64^a	81.65	11.73^a
90$_{(0\ DAS)}$ + 45 + 45	14.73^a	4.34^a	11.17^b	82.13	3.90^b
90$_{(15\ DAS)}$ + 45 + 45	15.01^a	4.31^a	11.16^b	81.45	4.52^b
60$_{(15\ DAS)}$ + 60 + 60	14.91^a	4.35^a	10.78^b	82.51	4.47^b
45$_{(15\ DAS)}$ + 90 + 45	14.78^a	4.28^a	11.55^b	82.68	4.82^b
SEm(±)	0.593	0.081	1.89	0.23	1.46
LSD (=0.05)	0.864	0.119	2.43	ns	2.76
Probability	<0.01	<0.01	<0.01	0.39	<0.01
CV, %	6.2	2.9	19.2	1.9	48.2
Grand mean	14.27	4.24	13.06	82.08	5.89

Note: LSD, least significant difference; ns, non-significant. Treatments means followed by common letter(s) within column are not significantly different among each other based on DMRT at 5% level of significance

3.4 Grain yield, stover yield and harvest index

3.4.1 Grain yield (kg ha^{-1})

The average grain yield of the experiment was 5847.88 kg ha^{-1}. Grain yield was significantly affected by the potassium application method. It was significantly higher in the potassium application of30 kg K_2O –basal + 30 kg K_2O – top dressing (6166.867 kg ha^{-1}) which was statistically at par with 60 kg K_2O – basal application (5831.70 kg ha^{-1}). Significantly lower grain yield was recorded in the control (5545.06 kg ha^{-1}).

Moreover, the nitrogen application method significantly affected the grain yield. Grain yield was significantly higher in the application of 1/2 N at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (6896.40 kg ha^{-1}) and it was statistically at par with N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (6556.98 kg ha^{-1}) and 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (6364.10 kg ha^{-1}). Intermediate grain yield was observed in the N application of 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (5953.76 kg ha^{-1}) whereas significantly lower grain yield was observed in control (3468.14 kg ha^{-1}).

3.4.2 Stover yield (kg ha^{-1})

The average stover produced in the experiment was 6774.36 kg ha^{-1}. There was non-significant effect of the potassium application method on stover yield. Relatively higher stover produced in the potassium application method of 30 kg K_2O –basal + 30 kg K_2O – top dressing (7000 kg ha^{-1}) as compared to 60 kg K_2O – basal application (6929.80 kg ha^{-1}) and control (6393.27 kg ha^{-1}).

Further, stover yield was significantly affected by the nitrogen application method. Significantly higher stover yield was recorded in the N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (8310.64 kg ha^{-1}) which was statistically at par with N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (7741.13 kg ha^{-1}). Intermediate stover yield was observed in the N application of 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (6953.97 kg ha^{-1}), 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (6810.04 kg ha^{-1}) whereas significantly lower stover yield was obtained in control (4055.99 kg ha^{-1}).

3.4.3 Harvest index

The average harvest index of the experiment was 43.36. Higher stover was produced as compared to grain. On average there was the production of 926.48 kg ha^{-1} stover than that of grain. Harvest index was not significantly affected by the potassium application method. A relatively higher harvest index was found in the potassium application of 30 kg K_2O –basal + 30 kg K_2O – top dressing (44.24) as compared to 60 kg K_2O – basal application (43.04) and control (42.78).

Similarly, the harvest index was not significantly affected by the nitrogen application method. Comparatively higher harvest index was observed in the N application of 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (44.69) and lowest in N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (41.07).

Table 10: Grain yield, stover yield and harvest index of winter maize hybrid as affected by split application of potassium and nitrogen at Rampur Chitwan, 2019/20

Treatments	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (HI)
Doses of potassium (kg ha^{-1})			
0	5545.06^{b}	6393.27	42.78
60	5831.70^{ab}	6929.80	43.04
30 + 30	6166.867^{a}	7000.00	44.24
SEm(±)	179.68	191.61	0.44
LSD (=0.05)	446.51	ns	ns
Probability	0.04	0.151	0.38
CV, %	7.5	10.7	6.2
Doses of nitrogen (kg ha^{-1})			
0	3468.14^{d}	4055.99^{c}	43.25
90$_{(0\ DAS)}$ + 45 + 45	6556.98^{ab}	8310.64^{a}	41.07
90$_{(15\ DAS)}$ + 45 + 45	6896.40^{a}	7741.13^{a}	44.22
60$_{(15\ DAS)}$ + 60 + 60	6364.10^{bc}	6953.97^{b}	44.69
45$_{(15\ DAS)}$ + 90 + 45	5953.76^{c}	6810.04^{b}	43.61
SEm(±)	614.12	732.04	0.61
LSD (=0.05)	497.51	761.96	ns
Probability	<0.01	<0.01	0.09
CV, %	5.7	11.6	6.5
Grand mean	5847.88	6774.36	43.36

Note: LSD, least significant difference; ns, non-significant. Treatments means followed by common letter (s) within column are not significantly different among each other based on DMRT at 5% level of significance

3.5 Potassium and nitrogen uptake in grain, stover and biomass

3.5.1 Potassium uptake

3.5.1.1 Potassium uptake in grain (kg/ha)

The average potassium uptake in grain was 31.57. Potassium uptake in grain was significantly affected by the potassium application method. Significantly higher potassium uptake in grain was recorded in the potassium application of 30 kg K_2O –basal + 30 kg K_2O – top dressing (36.98 kg ha^{-1}) as compared to 60 kg K_2O – basal application (31.45 kg ha^{-1}) and control (26.28 kg ha^{-1}).

Moreover, potassium uptake in grain was significantly affected by the nitrogen application method. Significantly higher potassium uptake in grain was found in the N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (41.39 kg ha^{-1}) as compared to other nitrogen application methods. The lowest potassium uptake in grain was observed in the control (14.50 kg ha^{-1}). Intermediate potassium uptake in grain was observed in the N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (36.01 kg ha^{-1}), 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (34.94 kg ha^{-1}), 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (30.91 kg ha^{-1}).

3.5.1.2 Potassium uptake in stover

The average potassium uptake in stover was 45.38 kg ha^{-1}. Potassium uptake in stover was significantly affected by the potassium application method. Significantly higher potassium uptake in stover was found in the potassium application of 30 kg K_2O –basal + 30 kg K_2O – top dressing (54.07 kg ha^{-1}) as compared to control (35.75 kg ha^{-1}) but statistically at par with 60 kg K_2O – basal application (46.32 kg ha^{-1}).

Further, potassium uptake in stover was significantly affected by the nitrogen application method. Significantly higher potassium uptake in stover recorded in the N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (58.95 kg ha^{-1}) as compared to 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (46.68 kg ha^{-1}), 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (44.88 kg ha^{-1}), and control (20.05 kg ha^{-1}) but it was statistically at par with N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (56.35 kg ha^{-1}).

3.5.1.3 Total potassium uptake in the grain and stover

On average uptake of 76.95 kg ha^{-1} potassium was observed in the experiment. Total potassium uptake was significantly affected by the potassium application method. Significantly higher total potassium uptake was observed in the potassium application of 30 kg K_2O –basal + 30 kg K_2O – top dressing (91.06 kg ha^{-1}) as compared to 60 kg K_2O – basal application (77.77 kg ha^{-1}) and control (62.03 kg ha^{-1}).

Moreover, total potassium uptake was significantly affected by the nitrogen application method. Significantly higher total potassium uptake was recorded in the N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (97.47 kg ha^{-1}) as compared to 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (81.62 kg ha^{-1}), 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (75.79 kg ha^{-1}), control (34.56 kg ha^{-1}) but it was statistically at par with N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (95.06 kg ha^{-1}).

3.5.2 Nitrogen uptake

3.5.2.1 Nitrogen uptake in grain

The average nitrogen uptake of grain in the experiment was 60.48 kg ha^{-1}. Nitrogen uptake in the grain was not significantly affected by the potassium application method. Relatively higher nitrogen uptake in grain was obtained in the potassium application of 30 kg K_2O –basal + 30 kg K_2O – top dressing (64.29 kg ha^{-1}) followed by 60 kg K_2O – basal application (61.44 kg ha^{-1}) and control (55.71 kg ha^{-1}).

However, nitrogen uptake in the grain was significantly higher in the nitrogen dose of N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (76.65 kg ha^{-1}) as compared to 45 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (58.66 kg ha^{-1}) and control (23.07 kg ha^{-1}) but it was statistically at par with N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (73.65 kg ha^{-1}) and 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (70.81 kg ha^{-1}).

3.5.2.2 Nitrogen uptake in stover

The average nitrogen uptake in the stover of maize in the experiment was 60.24 kg ha^{-1}. Nitrogen uptake in the stover was not significantly affected by the potassium application method. Relatively higher nitrogen uptake in stover was obtained in the potassium application of 30 kg K_2O –basal + 30 kg K_2O – top dressing (63.10 kg ha^{-1}) followed by 60 kg K_2O – basal application (62.26 kg ha^{-1}) and control (55.34 kg ha^{-1}).

However, nitrogen uptake in stover was significantly affected by the nitrogen application method. Significantly higher nitrogen uptake in stover was observed in the N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (79.37 kg ha^{-1}) as compared to N application of 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (59.59 kg ha^{-1}), 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (58.56 kg ha^{-1}) and control (28.72 kg ha^{-1}) but it was statistically at par with N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (74.93 kg ha^{-1}).

3.5.2.3 Total nitrogen uptake in grain and Stover

On average total nitrogen uptake in the experiment was 120.72 kg ha^{-1}. Total nitrogen uptake was not significantly affected by the potassium application methods. Comparatively higher total nitrogen uptake was observed in the potassium application of 30 kg K_2O –basal + 30 kg K_2O –top dressing (127.40 kg ha^{-1}) and lowest in control (111.40 kg ha^{-1}).

Table 11: Potassium and nitrogen uptake in grain and stover of winter maize hybrid as affected by split application of potassium and nitrogen at Rampur Chitwan, 2019/20

Treatments	K uptake in Grain (kg ha^{-1})	K uptake in stover (kg ha^{-1})	Total K uptake (kg ha^{-1})	N uptake in Grain (kg ha^{-1})	N uptake in stover (kg ha^{-1}))	Total N Uptake (kg ha^{-1})
Doses of potassium (kg ha^{-1})						
0	26.28^{c}	35.75^{b}	62.03^{c}	55.71	55.34	111.40
60	31.45^{b}	46.32^{a}	77.77^{b}	61.44	62.26	123.40
30 + 30	36.98^{a}	54.07^{a}	91.06^{a}	64.29	63.10	127.40
SEm(±)	3.08	5.31	8.38	2.52	2.45	4.94
LSD (0.05)	2.35	10.30	12.25	ns	ns	ns
Probability	<0.01	0.019	<0.01	0.084	0.63	0.11
CV, %	7.4	22.4	15.7	12.6	38.1	14
Doses of nitrogen (kg ha^{-1})						
0	14.50^{d}	20.05^{c}	34.56^{c}	23.07^{c}	28.72^{c}	51.80^{c}
90$_{(0\ DAS)}$ + 45 + 45	36.10^{b}	58.95^{a}	95.06^{a}	76.65^{a}	74.93^{a}	151.15^{a}
90$_{(15\ DAS)}$ + 45 + 45	41.39^{a}	56.35^{a}	97.74^{a}	73.65^{a}	79.37^{a}	153.02^{a}
60$_{(15\ DAS)}$ + 60 + 60	34.94^{b}	46.68^{b}	81.62^{b}	70.81^{a}	59.59^{b}	130.41^{b}
45$_{(15\ DAS)}$ + 90 + 45	30.91^{c}	44.88^{b}	75.79^{b}	58.66^{b}	58.56^{b}	117.234^{b}
SEm(±)	4.58	6.88	11.35	9.82	8.88	18.47
LSD (=0.05)	3.06	5.34	6.51	8.90	8.02	15.10
Probability	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CV, %	10	12.1	8.7	15.1	13.7	12.9
Grand mean	**31.57**	**45.38**	**76.95**	**60.48**	**60.24**	**120.72**

Note: LSD, least significant difference; ns, non-significant. Treatments means followed by common letter(s) within column are not significantly different among each other based on DMRT at 5% level of significance

But total nitrogen uptake was significantly affected by the nitrogen application method. Significantly higher total nitrogen uptake was recorded in the N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (153.02 kg ha^{-1}) as compared to N application of 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (59.59 kg ha^{-1}), 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (58.56 kg ha^{-1}) and control (51.80 kg ha^{-1}) but it was statistically at par with 90 $_{(0\ DAS)}$ + 45 + 45 (151.15 kg ha^{-1}). Total nitrogen uptake in the N application of 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling and 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling was statistically at par but uptake was significantly higher than control.

Table 12: Potassium uptake in stover (kg K ha^{-1}) and total potassium uptake (kg K ha^{-1}) of winter maize hybrid as affected by interaction of split application of potassium and nitrogen at Rampur Chitwan, 2019/20

Doses of nitrogen (kg ha^{-1})	Potassium Uptake in Stover			Total Potassium Uptake		
	Doses of Potassium (kg ha^{-1})					
	0	60	30 + 30	0	60	30 + 30
0	17.91^{h}	18.70^{h}	23.55^{h}	28.77^{i}	33.93^{hi}	40.99^{h}
90$_{(0\ DAS)}$ + 45 + 45	44.97^{efg}	58.38^{bc}	73.49^{a}	77.08^{ef}	91.45^{bcd}	116.64^{a}
90$_{(15\ DAS)}$ + 45 + 45	41.72^{efg}	58.94^{b}	68.37^{a}	77.44^{ef}	99.75^{b}	116.02^{a}
60$_{(15\ DAS)}$ + 60 + 60	37.75^{fg}	47.06^{def}	55.23^{bcd}	66.16^{fg}	83.83^{cde}	94.88^{bc}
45$_{(15\ DAS)}$ + 90 + 45	36.40^{g}	48.51^{cde}	49.72^{bcde}	60.70^{g}	79.92^{de}	86.75^{cde}

Note: Treatments means followed by common letter(s) within column are not significantly different among each other based on DMRT at 5% level of significance

Potassium uptake in stover was significantly higher in the potassium application of 30 kg K_2O –basal + 30 kg K_2O – top dressing and N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling as compared to other combinations but it was statistically at par with potassium uptake in potassium application of 30 kg K_2O –basal + 30 kg K_2O – top dressing and N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling. In the potassium application of 60 kg K_2O – basal application, higher potassium uptake was recorded in the N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling which was statistically similar with N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling. In the control plot of potassium, higher potassium uptake in stover was observed in the N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling.

Total potassium uptake was significantly higher in the potassium application of 30 kg K_2O –basal + 30 kg K_2O – top dressing and N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling as compared to other combinations but it was statistically at par with potassium uptake in potassium application of 30 kg K_2O –basal + 30 kg K_2O – top dressing and N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling. In the potassium application of 60 kg K_2O – basal application, higher potassium uptake was recorded in the N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling which was statistically similar with N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling. In the control plot of potassium, higher potassium uptake was recorded in the N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling which was statistically similar with N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling and N application of 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling.

3.5.3 Relationship between grain yield ad stover yield with grain K uptake, stover K uptake, grain N uptake, stover N uptake, and total uptake

Grain yield obtained was significantly associated with grain K uptake, grain N uptake, total K uptake, and total N uptake. Similarly, stover yield was associated with stover K uptake and stover N uptake.

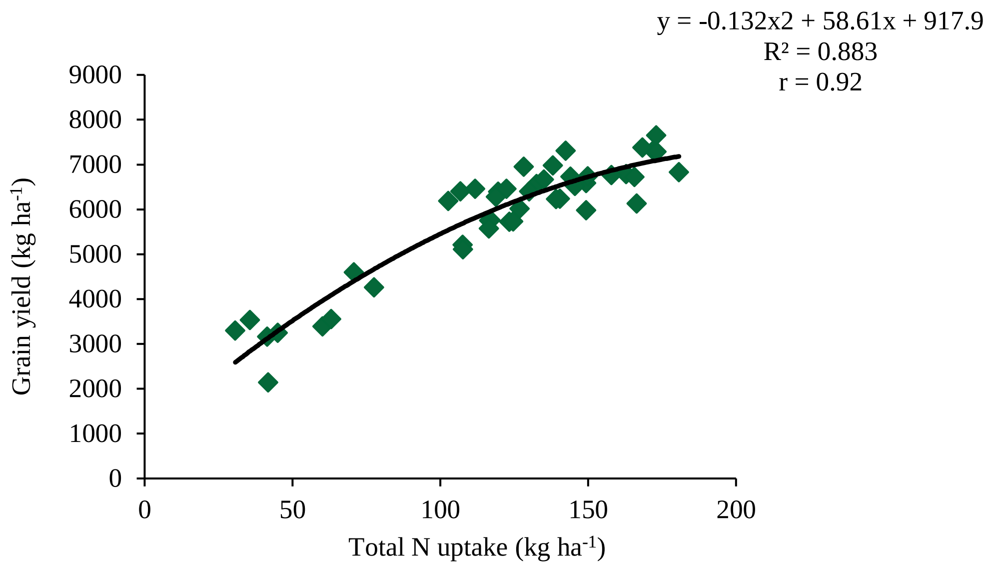

Figure 1: Correlation between grain yield and total nitrogen uptake on field experiment at Rampur, Chitwan, 2019/20

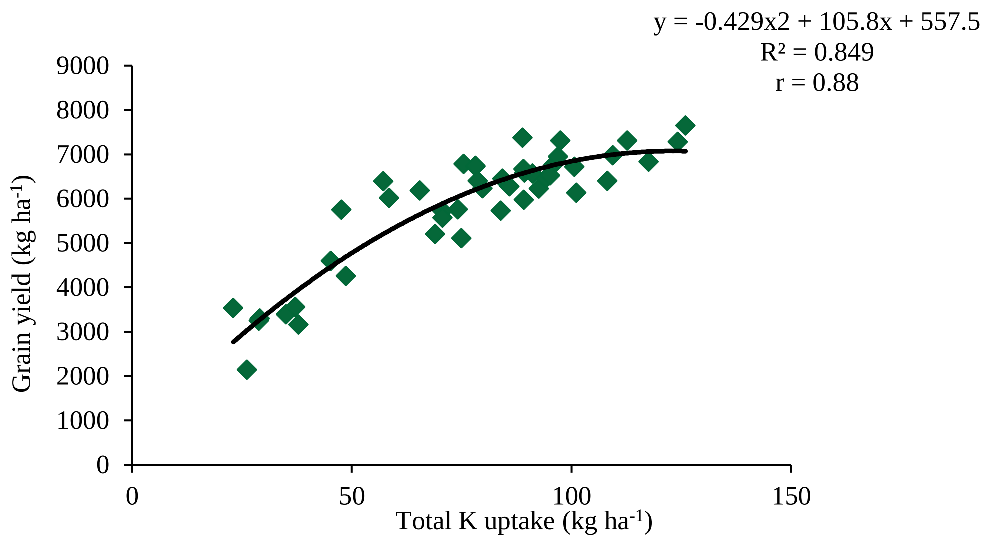

Figure 2: Correlation between grain yield and total K uptake on field experiment at Rampur, Chitwan, 2019/20

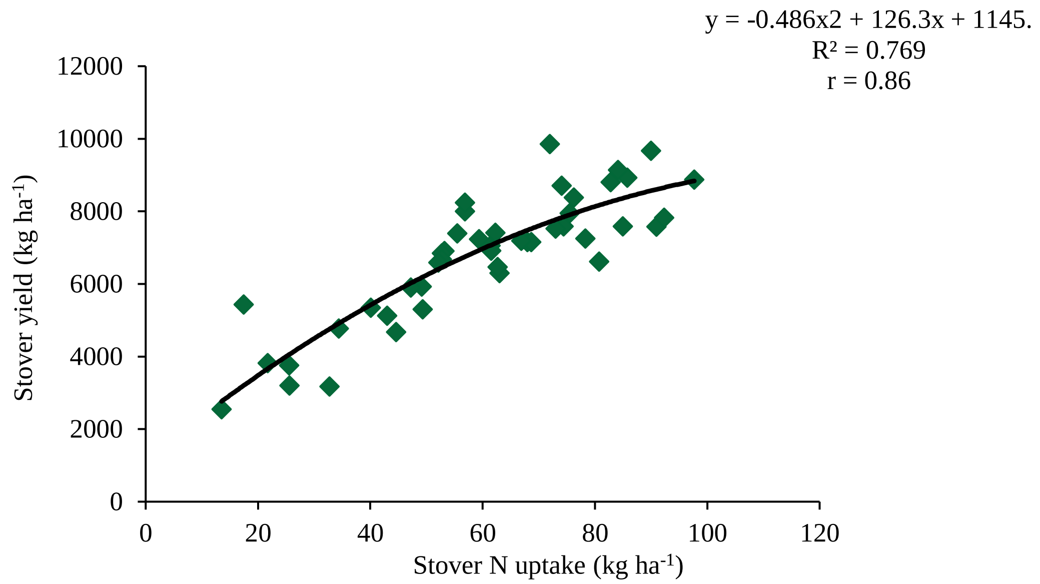

Figure 3: Correlation between stover yield and N uptake in stover on field experiment at Rampur, Chitwan, 2019/20

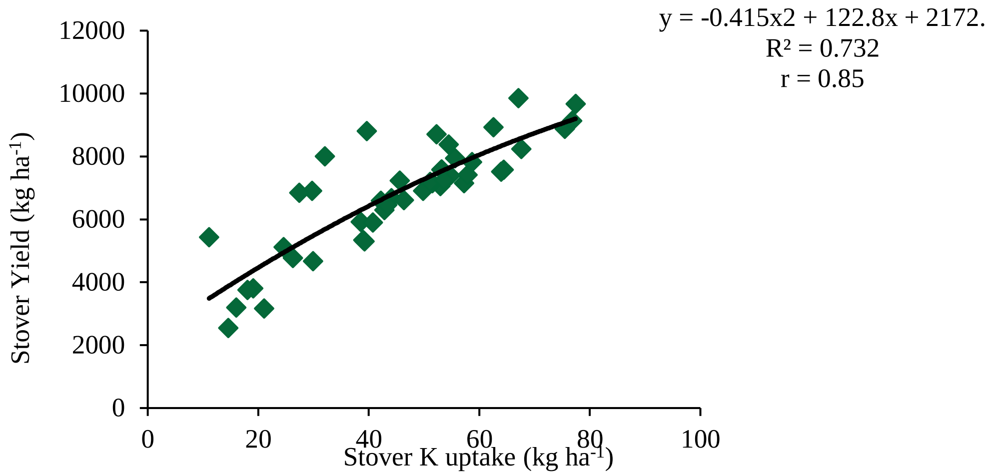

Figure 4: Correlation between stover yield and K uptake in stover on field experiment at Rampur, Chitwan, 2019/20

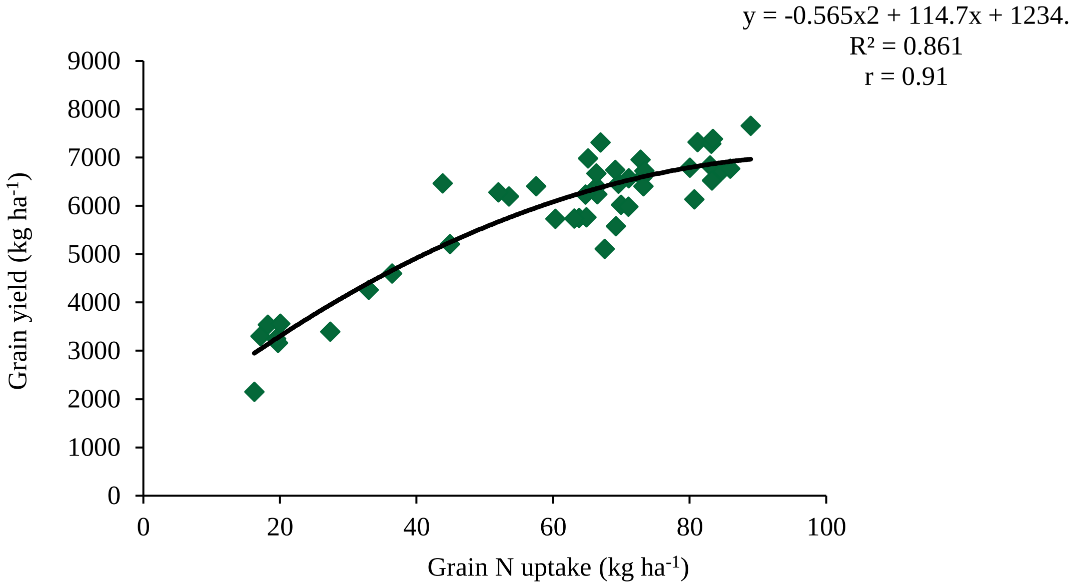

Figure 5: Correlation between grain yield and N uptake in grain on field experiment at Rampur, Chitwan, 2019/20

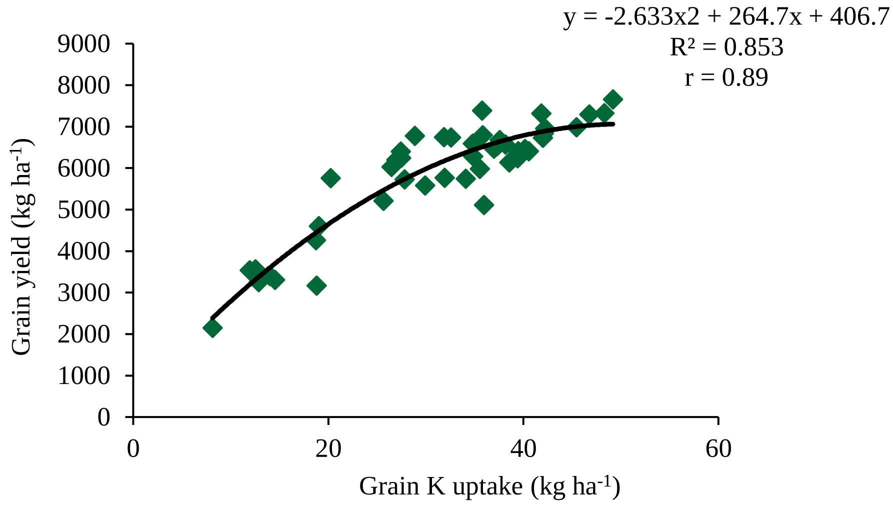

Figure 6: Correlation between grain yield and K uptake in grain on field experiment at Rampur, Chitwan, 2019/20

3.6 Efficiency of potassium and nitrogen

3.6.1 Agronomic use efficiency

3.6.1.1 Agronomic use efficiency of potassium (kg grain kg^{-1} K applied)

The average agronomic use efficiency of potassium was 10.55. the agronomic use efficiency of potassium was not significantly affected by the potassium application method. Relatively higher agronomic use efficiency of potassium was recorded in the potassium application of 30 kg K_2O – basal + 30 kg K_2O – top dressing (11.57) as compared to 60 kg K_2O – basal application (9.52).

Similarly, the agronomic use efficiency of potassium was not significantly affected by the nitrogen application method. Comparatively higher agronomic use efficiency of potassium was observed in the nitrogen dose of 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (13.11) and lowest agronomic use efficiency found in the control (8.89).

3.6.1.2 Agronomic use efficiency of nitrogen (kg grain kg-1 N applied)

On average agronomic use efficiency of the nitrogen was 14.55. the agronomic use efficiency of nitrogen was not significantly affected by the potassium application method. Comparatively higher AE of nitrogen was observed in the potassium application of 30 kg K_2O –basal + 30 kg K_2O – top dressing (15.20) followed by 60 kg K_2O – basal application (13.45) and control (13.35).

However, the agronomic use efficiency of nitrogen significantly was affected by the nitrogen application method. Significantly higher AE of nitrogen recorded in the N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (16.76) as compared to N application of 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (14.21) and 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (12.15) but it was statistically at par with N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (15.10).

3.6.2 Recovery efficiency

3.6.2.1 Recovery efficiency of potassium (kg K uptake kg-1 K applied)

The average recovery efficiency of the potassium was 0.47. The recovery efficiency of potassium was not significantly affected by the potassium application method. The higher recovery efficiency of potassium was observed in the potassium application of 30 kg K_2O –basal + 30 kg K_2O – top dressing (0.49) as compared to 60 kg K_2O – basal application (0.45).

Further, the recovery use efficiency of potassium was significantly affected by the nitrogen application method. Significantly higher recovery use efficiency of potassium was observed in the N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (0.56) which was statistically at par with 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (0.54). the significantly lower recovery efficiency of potassium was observed in the control (0.29)

3.6.2.2 Recovery efficiency of nitrogen (kg N uptake kg-1 N applied)

The average recovery efficiency of nitrogen was 0.47. The recovery efficiency of nitrogen was not significantly affected by the potassium dose. The relatively higher recovery efficiency of nitrogen was found in the 30 kg K_2O –basal + 30 kg K_2O – top dressing (0.51) followed by 60 kg K_2O – basal application (0.47) and control (0.43).

However, the recovery efficiency of nitrogen was significantly affected by the nitrogen application method. Significantly higher recovery efficiency was observed in the N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (0.56) as compared to other nitrogen application methods but it was statistically at par with N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (0.53).

3.6.3 Partial factor productivity

3.6.3.1 Partial factor productivity of potassium (kg grain kg-1 K applied)

The mean partial factor productivity was 59.99. Partial factor productivity of potassium was not significantly affected by the potassium application method. Comparatively higher partial factor productivity of potassium was observed in the 30 kg K_2O –basal + 30 kg K_2O – top dressing (102.78) as compared to 60 kg K_2O – basal application (97.19).

Moreover, partial factor productivity of potassium was significantly affected by the nitrogen method. Significantly higher partial factor productivity of potassium was observed in the N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (117.02) and significantly lower partial factor productivity of potassium was found in the control plot of nitrogen (61.02).

3.6.3.2 Partial factor productivity of nitrogen (kg grain kg-1 N applied)

The average partial factor productivity of nitrogen of the experiment was 21.47. Partial factor productivity of nitrogen was significantly affected by the potassium application method. Significantly higher partial factor productivity of nitrogen was recorded in the 30 kg K_2O –basal + 30 kg K_2O – top dressing (48.51) as compared to control (44.64) and it was statistically at par with 60 kg K_2O – basal application (46.90).

However, partial factor productivity of nitrogen was significantly affected by the nitrogen application method. Significantly higher partial factor productivity of nitrogen was observed in the N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (49.97) which was statistically similar with N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (47.51) and 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (46.11). Significantly lower partial factor productivity of nitrogen was recorded in the N application of 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (43.14).

Table 13: Efficiency of potassium and nitrogen of winter maize hybrid as affected by split application of potassium and nitrogen at Rampur Chitwan, 2019/20

Treatments	AE_K (Kg grain kg-1 K applied)	AE_N (Kg grain kg-1 N applied)	RE_K (Kg K Uptake kg-1 K applied)	RE_N (Kg N Uptake kg-1 N applied)	PFP_K (kg grain kg-1 K applied)	PFP_N (kg grain kg-1 N applied)
Doses of potassium (kg ha-1)						
0	-------	13.45	-------	0.43	-------	44.64^{b}
60	9.52	15.00	0.45	0.47	97.19	46.90^{ab}
30 + 30	11.57	15.20	0.49	0.51	102.78	48.51^{a}
SEm(±)	1.02	0.554	0.02	0.02	2.79	1.12
LSD (=0.05)	ns	ns	ns	ns	ns	2.66
Probability	0.21	0.40	0.24	0.47	0.23	0.03
CV, %	29.5	21.3	16.2	33	8.9	5
Doses of nitrogen (kg ha-1)						
0	8.89	-------	0.29^{c}	-------	61.02^{c}	-------
$90_{(0\ DAS)}$ + 45 + 45	9.00	15.10^{ab}	0.54^{ab}	0.53^{a}	110.75^{ab}	47.51^{a}
$90_{(15\ DAS)}$ + 45 + 45	11.99	16.76^{a}	0.56^{a}	0.56^{a}	117.02^{a}	49.97^{a}
$60_{(15\ DAS)}$ + 60 + 60	11.21	14.21^{b}	0.48^{b}	0.43^{b}	109.93^{ab}	46.11^{ab}
$45_{(15\ DAS)}$ + 90 + 45	11.63	12.15^{c}	0.49^{b}	0.36^{b}	101.19^{b}	43.14^{b}
SEm(±)	0.66	0.959	0.04	0.04	10.06	1.42
LSD (=0.05)	NS	1.91	0.061	0.07	9.26	3.83
Probability	0.42	<0.01	<0.01	<0.01	<0.01	0.011
CV, %	34.1	13.3	10.5	16.6	7.6	8.3
Grand mean	10.55	14.55	0.47	0.47	59.99	21.47

Note: LSD, least significant difference; AE, agronomic efficiency; RE, recovery efficiency; PFP, partial factor productivity; ns, non-significant. Treatments means followed by common letter(s) within column are not significantly different among each other based on DMRT at 5% level of significance

3.7 Economic analysis

3.7.1 Cost of production

The cost of production was greatly affected by the nitrogen application method and potassium application method. On average the total cost of the experiment was 93568 NRs ha^{-1}. The cost of production was significantly affected by the potassium application method. A significantly higher cost of production was observed in the 30 kg K_2O –basal + 30 kg K_2O – top dressing (95200 NRs ha^{-1}) than 60 kg K_2O – basal application (94000 NRs ha^{-1}). A significantly lower cost of production was found in the control (91500 NRs ha^{-1}).

The cost of production was significantly differed by the nitrogen application method. Significantly higher cost of production was observed in the N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (95500 NRs ha^{-1}), 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (95500 NRs ha^{-1}), and 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (95500 NRs ha^{-1}) as compared to N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (93660 NRs ha^{-1}) and control (87670 NRs ha^{-1}). A significantly lower cost of production was recorded in the control as compared to other treatments.

3.7.2 Gross return

The overall gross return of the experiment was 22161 NRs ha^{-1}. Gross return showed a significant difference with the potassium application method. Potassium application of 30 kg K_2O –basal + 30 kg K_2O – top dressing produced significantly higher gross return (233340 NRs ha^{-1}) as compared to 60 kg K_2O – basal application (221430 NRs ha^{-1}) and control (210060 NRs ha^{-1}).

Further, the gross return was significantly higher in the N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (260720 NRs ha^{-1}) which was statistically at par with N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (250270 NRs ha^{-1}). Gross return in control was found significantly lower (131520 NRs ha^{-1}) as compared to other nitrogen application methods.

3.7.3 Net return

On average, net return of the experiment was 128460 NRs ha^{-1}. Net return was not significantly affected by the potassium application method. Relatively higher net return was found in the Potassium application of 30 kg K_2O –basal + 30 kg K_2O – top dressing (138140 NRs ha^{-1}) as compared to 60 kg K_2O – basal application (127430 NRs ha^{-1}) and control (119820 NRs ha^{-1}).

Further, net return was significantly higher in the nitrogen application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (165220 NRs ha^{-1}) and it was statistically at par with N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (156600 NRs ha^{-1}). Other nitrogen application methods produced a lower net return. Net return was found significantly lower in the control (45950 NRs ha^{-1}).

3.7.4 Benefit cost ratio (BCR)

On average, benefit cost ratio of the experiment was 2.35. Potassium application method non-significantly affected benefit cost ratio. Relatively higher gross return was found in the 30 kg K_2O –basal + 30 kg K_2O – top dressing (2.44). A lower BCR was found in the control (2.30).

Moreover, BCR was significantly higher in the N application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (2.72) as compared to N application of 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling (2.51), 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling (2.35) and control (1.49) but it was statistically at par with N application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling (2.67).

Table 14: Cost, gross return, net return and BCR of winter maize hybrid as affected by split application of potassium and nitrogen at Rampur Chitwan, 2019/20

Treatments	Variable cost ('000 NRs ha^{-1})	Gross return ('000 NRs ha^{-1})	Net Return ('000 NRs ha^{-1})	BCR
Doses of potassium (kg ha^{-1})				
0	91.50	210.06^{b}	119.82	2.28
60	94.00	221.43^{ab}	127.43	2.34
30 + 30	95.20	233.34^{a}	138.14	2.44
SEm(±)		6.72	5.31	0.04
LSD (=0.05)		16.01	ns	ns
Probability		0.03	0.06	0.14
CV, %		7.1	11.4	7.3
Doses of nitrogen (kg ha^{-1})				
0	87.67	131.52^{d}	45.95^{d}	1.49^{d}
$90_{(0\ DAS)}$ + 45 + 45	93.66	250.27^{ab}	156.60^{ab}	2.67^{ab}
$90_{(15\ DAS)}$ + 45 + 45	95.50	260.72^{a}	165.22^{a}	2.72^{a}
$60_{(15\ DAS)}$ + 60 + 60	95.50	240.12^{bc}	144.62^{bc}	2.51^{bc}
$45_{(15\ DAS)}$ + 90 + 45	95.50	225.40^{c}	129.90^{c}	2.35c
SEm(±)		23.26	21.46	022
LSD (0.05)		18.41	17.73	0.19
Probability		<0.01	<0.01	<0.01
CV, %		8.5	14.2	8.7
Grand mean	93.56	221.61	128.46	2.35

Note: LSD, least significant difference; BCR, Benefit to cost ratio; ns, non-significant. Treatments means followed by common letter(s) within column are not significantly different among each other based on DMRT at 5% level of significance

4. Conclusion

Maize cultivation with the split application of potassium; 30 kg K_2O –basal + 30 kg K_2O – the top dressing was similar with 60 kg K_2O – basal application in terms of yield and economics of production of Rampur hybrid-10. Nitrogen application of 1/2 at 15 DAS + 1/4 at Knee high + 1/4 at Tasseling (Starter application) was similar with nitrogen application of 1/2 – basal + 1/4 at Knee high + 1/4 at Tasseling in terms of grain yield and economics of production but superior to nitrogen application of 1/3 at 15 DAS + 1/3 at Knee high + 1/3 at Tasseling and nitrogen application of 1/4 at 15 DAS + 1/2 at Knee high + 1/4 at Tasseling. This suggests that the starter application of nitrogen in the splitting (1/2 + 1/4 + 1/4) results in better yield and nutrient uptake.

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