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Effect of different levels of NPK on growth, quality and nutrient uptake in gomphrena (*Gomphrena globosa* L.)

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Abstract
The present investigation was carried out at Floriculture Farm, Jambuvadi, Department of Horticulture, Junagadh Agricultural University, Junagadh (Gujarat). The experiment was conducted in Randomized Block Design with a factorial concept having twelve treatment combinations, consisting of three levels of nitrogen (100, 150 and 200 kg ha^{-1}), two levels of phosphorus (50 and 75 kg ha^{-1}) and two levels of potassium (75 and 100 kg ha^{-1}). The result of the experiment revealed that the effect of nitrogen at 200 kg ha^{-1}, phosphorus at 75 kg ha^{-1}, and potassium at 100 kg ha^{-1} respectively recorded maximum plant height (36.16 cm, 35.57 cm, 35.42 cm), number of branches per plant (11.58, 11.11, 11.29), plant spread (N-S) (23.97 cm, 23.78 cm, 23.66 cm), plant spread (E-W) (30.89 cm, 30.24 cm, 30.42 cm), fresh weight of plant (333.57 g, 327.02 g, 326.99 g), dry weight of plant (110.99 g, 106.94 g, 107.45 g), vase life (6.98 days, 6.47 days, 6.56 days), shelf life (27.02 days, 26.59 days, 26.43 days), higher nitrogen uptake (3.02 g $plant^{-1}$, 2.48 g $plant^{-1}$, 2.39 g $plant^{-1}$), phosphorus uptake (0.39 g $plant^{-1}$, 0.37 g $plant^{-1}$, 0.36 g $plant^{-1}$) and potassium uptake (2.24 g $plant^{-1}$, 2.08 g $plant^{-1}$, 2.10 g $plant^{-1}$).

Keywords: NPK, growth, quality, nutrient uptake, *Gomphrena globosa* L.

Introduction

Gomphrena, a native plant of North America, South America, Myanmar, and India, belongs to the family Amaranthaceae and is widely cultivated for its vibrant and button-like flower heads. It typically grows up to 1-2 feet tall with erect, branched stems and oblong-ovate leaves. They thrive as an annual plant in warm temperate to tropical climates with temperatures ranging from 20 to 35 °C and an annual rainfall of 900 to 3000 mm. Gomphrena also excels as a dried flower, making it ideal for dry flower arrangements, indoor decorations, pomanders, garlands, bouquets, and vase arrangements. Gomphrena flowers contain betacyanin, including gomphrenin and isogomphrenin, which are red-violet betalain pigments. (Roriz *et al.*, 2017) [25]. Plant parts are mainly used to treat body soreness, malaria, bacterial infections and jaundice, urinary problem, high cholesterol, cough, fever, diarrhea, liver disorders, kidney disorders and cooling. (Anaswara *et al.*, 2022) [2].

Proper application of nitrogen (N), phosphorus (P), and potassium (K) fertilizers is crucial for the optimal growth and flowering of gomphrena.

Nitrogen (N) is a vital nutrient that significantly impacts plant growth and yield. It is a key component of chlorophyll, facilitating photosynthesis and the production of sugars from water and carbon dioxide. It also promotes lush green foliage, encourages vegetative growth in leaves and stems, enhances nutrient uptake, including potassium and phosphorus, and regulates overall plant growth. (Leghari *et al.*, 2016) [15].

Phosphorus (P) is another vital nutrient necessary for gomphrena's growth. It serves as a component of various structural compounds in plants and catalyzes important biochemical reactions. Adding phosphorus to crops has been associated with stimulating root development, strengthening stalks and stems, improving flower formation and seed production, promoting earlier and more uniform flower maturity, and enhancing flower quality. (Razaq *et al.*, 2017) [22].

Potassium (K) is an essential activator of numerous vital enzymes involved in various plant processes. It is necessary for protein synthesis, sugar transport, nitrogen and carbon metabolism, and photosynthesis. Potassium significantly influences yield formation and quality improvement. Potassium activates ATPase in the plasma membrane, triggering acid stimulation, cell wall loosening, and hydrolase activation, thereby promoting cell growth. (Hepler *et al.*, 2001) [12].

Materials and Methods

The present investigation was conducted at Floriculture Farm, Jambuvadi, Department of Horticulture, Junagadh Agricultural University, Junagadh (Gujarat) during the year 2022. There were twelve different treatment combinations comprising three levels of nitrogen (N_1 = 100 kg ha^{-1}, N_2 = 150 kg ha^{-1} and N_3 = 200 kg ha^{-1}), two levels of phosphorus (P_1 = 50 kg ha^{-1} and P_2 = 75 kg ha^{-1}) and two levels of potassium (K_1 = 75 kg ha^{-1} and K_2 = 100 kg ha^{-1}), which were applied in the form of urea, single super phosphate (SSP) and muriate of potash (MOP), respectively. Urea was applied in two split doses, along with full doses of SSP and MOP. The remaining dose of urea was applied a month later. The experiment was laid out in Factorial Randomised Block Design (FRBD) and replicated three times. Forty days old healthy seedlings of gomphrena were then transplanted with a spacing of 30 x 20 cm.

Results and Discussion

Growth parameters

Effect of nitrogen

The result pointed out that plant height was found significantly maximum (36.16 cm) in treatment N_3 (200 kg ha^{-1}) and minimum (32.66 cm) in treatment N_1 (100 kg ha^{-1}). Nitrogen being an important constituent of various enzymes which take part in plant metabolism, it plays an active role in energy metabolism. Therefore, increasing the levels of nitrogen improved cell division and cell elongation which might have resulted in maximum plant height. Similar results were reported by Barad *et al.* (2015) [4] and Agrawal and Dorajeerao (2016) [1] in golden rod, Kejkar and Polara (2017) [13] in spider lily, and Vinayak *et al.* (2017) [32] in salvia.

Whereas the number of primary branches was significantly highest (11.58) in treatment N_3 (200 kg ha^{-1}) and lowest (9.53) in treatment N_1 (100 kg ha^{-1}). Nitrogen supply to roots is found to stimulate the production and export of cytokinin to the shoots, which might have caused the lateral buds to sprout giving more primary branches. These readings were in close similarity to those of Dedhia *et al.* (2021) [6] in gaillardia and Ghormade *et al.* (2018) [10] in China aster.

In terms of plant spread (N-S) and (E-W), significantly maximum plant spread (23.97 cm and 30.89 cm respectively) was observed in treatment N_3 (200 kg ha^{-1}). Likewise, the minimum (20.93 cm and 27.11 cm) plant spread (N-S) and (E-W) respectively were seen in treatment N_1 (100 kg ha^{-1}). This rise in plant spread may be attributed to the association of nitrogen in the synthesis of protoplasm and primarily in the formation of amino acids and increase in auxin activities due to nitrogen fertilization. These results were in close conformity to that of Singh *et al.* (2014) [29] in tuberose, Fayaz *et al.* (2016) [9] in gerbera and Barad *et al.* (2015) [4] in golden rod.

The fresh weight and dry weight of plant (333.57 g and 110.99 g respectively) were significantly maximum in treatment N_3 (200 kg ha^{-1}). Similarly, minimum fresh weight and dry weight (302.15 g and 94.92 g) were seen in treatment N_1 (100 kg ha^{-1}). The increase in weight of the plant might be due to an increase in plant height, plant spread and the number of branches per plant. These observations are following the findings of Rajan *et al.* (2019) [21] in chrysanthemum and Savaliya *et al.* (2019) [27] in golden rod.

Effect of phosphorus

Significantly maximum (35.57 cm) plant height was observed in treatment P_2 (75 kg ha^{-1}) and a minimum (33.51 cm) in treatment P_1 (50 kg ha^{-1}). The possible reason for the increase in plant height might be attributed to the fact that phosphorus is one of the major elements and a constituent of nucleoprotein, which plays a leading role in cell division and tissue formation. Similar findings were observed by Kumar *et al.* (2006) [14] and Patel *et al.* (2010) [19] in gladiolus and Kejkar and Polara (2017) [13] in spider lily.

Among the different phosphorus levels, the number of primary branches was significantly maximum (11.11) in treatment P_2 (75 kg ha^{-1}) and minimum (10.10) in treatment P_1 (50 kg ha^{-1}). Since phosphorus is an integral part of sugar phosphate (ATP and ADP) and necessary for photosynthetic and respiratory processes, this might be the reason for the increase in the number of primary branches. These results are in close conformity with the findings of Chaudhary *et al.* (2016) [5] in rose and Ozukum *et al.* (2022) [17] in jasmine.

The plant spread (N-S) and (E-W) were significantly maximum (23.78 cm and 30.24 cm respectively) in treatment P_2 (75 kg ha^{-1}). Similarly, minimum plant spread (N-S) and (E-W) (21.03 cm and 27.85 cm respectively) in treatment P_1 (50 kg ha^{-1}). The reason could be that phosphorus promotes root development and branching, which leads to better nutrient and water absorption, resulting in healthier plants with larger plant spread. These findings are in corroboration to Rajan *et al.* (2019) [21] in chrysanthemum and Savaliya *et al.* (2019) [27] in golden rod.

It was noted that significantly maximum fresh weight and dry weight of the plant (327.02 g and 106.94 g respectively) was observed in treatment P_2 (75 kg ha^{-1}). Whereas, minimum plant fresh weight and dry weight (310.47 g and 99.54 g) were observed in treatment P_1 (50 kg ha^{-1}). The increase in plant weight might be due to the reason that phosphorus promotes cell division and cell elongation leading to enhanced vegetative growth. These findings were in close similarity to those observed by Rajan *et al.* (2019) [21] in chrysanthemum and Savaliya *et al.* (2019) [2] in golden rod.

Effect of potassium

Plant height was significantly maximum (35.42 cm) in treatment K_2 (100 kg ha^{-1}) and minimum (33.65 cm) in treatment K_1 (75 kg ha^{-1}). In terms of the growth-promoting mechanism, potassium stimulates and controls ATPase in the plasma membrane to generate acid stimulation, which then triggers cell wall loosening, thus promoting cell growth which might be the reason for increased plant height. These results were in close conformity to that of Zeb *et al.* (2015) [33] in chrysanthemum and Gupta *et al.* (2016) [11] in dahlia.

Among the different potassium levels, the number of primary branches were significantly highest (11.29) in treatment K_2 (100 kg ha^{-1}) and lowest (9.92) in treatment K_1 (75 kg ha^{-1}). Potassium is involved in the production of some plant hormones like auxin and cytokinin, which stimulate cell division and cell elongation, which might be the reason for the increased number of primary branches. Similar findings were observed by Rajadurai *et al.* (2000) [20] in marigold and Sahu *et al.* (2021) [26] in chrysanthemum.

The plant spread (N-S) and (E-W) were significantly maximum (23.66 cm and 30.42 cm respectively) in treatment K_2 (100 kg ha^{-1}). Whereas minimum plant spread (N-S) and (E-W) (21.15 cm and 27.67 cm respectively) were observed in treatment K_1 (75 kg ha^{-1}). Potassium promotes root growth, which allows the plant to absorb more water and nutrients, thereby increasing the rate of photosynthesis which might be the cause of improved plant growth and plant spread. These results were in close similarity to that of Singh *et al.* (2017) [30] in China aster and Savaliya *et al.* (2019) [27] in golden rod and Parasana *et al.* (2023) [18] in custard apple.

The fresh weight and dry weight of the plant (326.99 g and 107.45 g) was significantly highest in treatment K_2 (100 kg ha^{-1}). Similarly, minimum plant fresh weight and dry weight (310.50 g and 99.03 g) was observed in treatment K_1 (75 kg ha^{-1}). The surge in plant weight might be due to an increase in plant height, plant spread (N-S) (E-W) and the number of branches per plant. These observations were closely similar to that of Savaliya *et al.* (2019) [27] in golden rod, Reshma (2018) [24] in gomphrena and Vasava *et al*. (2023) [32] in brinjal.

Interaction effect of N and P

Significantly maximum N-S plant spread (32.90 cm) and E-W plant spread (25.06 cm) were noted in treatment combination N_3P_2 (200: 75 kg ha^{-1}). These results were in close similarity to that of Singh *et al.* (2017) [30] in China aster and Savaliya *et al.* (2019) [27] in golden rod. This might be due to the reason that nitrogen and phosphorus at the above rates were ideal for increasing the plant spread of gomphrena.

Interaction effect of N, P and K

Significantly maximum plant height (38.95 cm), number of primary branches (13.14), plant fresh weight (369.74 g) and plant dry weight (117.20 g) were noted in treatment combination $N_3P_2K_2$ (200: 75: 100 kg ha^{-1}). These results were in close similarity to that of Ozukum *et al.* (2022) [17] in jasmine and Aremsungla and Topno (2022) [3] in zinnia. This might be due to the reason that nitrogen, phosphorus and potassium at the above rates were ideal for increasing the growth parameters of gomphrena.

Quality parameters

Effect of nitrogen

Significantly maximum vase life and shelf life (6.98 days and 27.02 days) was observed in treatment N_3 (200 kg ha^{-1}) whereas minimum vase life and shelf life (5.58 days and 23.98 days) was found in treatment N_1 (100 kg ha^{-1}). This might be due to the reason that nitrogen is necessary for production of amino acids, which are building blocks of proteins. Proteins are important for maintaining the quality and appearance of flowers. These findings were similar to that of Singh *et al.* (2013) [31] and Regar *et al.* (2016) [23] in gladiolus and Aremsungla and Topno (2022) [3] in zinnia.

Table 1: Effect of different levels of NPK on growth parameters

Treatment	Plant height (cm)	Number of primary branches	Plant spread (N-S) (cm)	Plant spread (E-W) (cm)	Fresh weight of plant (g)	Dry weight of plant (g)
Nitrogen (N)						
N_1 = 100 kg ha^{-1}	32.66	9.53	20.93	27.11	302.15	94.92
N_2 = 150 kg ha^{-1}	34.78	10.71	22.34	29.15	320.53	103.81
N_3 = 200 kg ha^{-1}	36.16	11.58	23.97	30.89	333.57	110.99
S.Em ±	0.598	0.197	0.547	0.619	6.349	2.08
C. D. @ 5%	1.75	0.57	1.60	1.81	18.62	6.10
Phosphorus (P)						
P_1 = 50 kg ha^{-1}	33.51	10.10	21.03	27.85	310.47	99.54
P_2 = 75 kg ha^{-1}	35.57	11.11	23.78	30.24	327.02	106.94
S.Em ±	0.488	0.161	0.447	0.506	5.184	1.699
C. D. @ 5%	1.43	0.47	1.31	1.48	15.20	4.98
Potassium (K)						
K_1 = 75 kg ha^{-1}	33.65	9.92	21.15	27.67	310.50	99.03
K_2 = 100 kg ha^{-1}	35.42	11.29	23.66	30.42	326.99	107.45
S.Em ±	0.488	0.161	0.447	0.506	5.184	1.699
C. D. @ 5%	1.43	0.47	1.31	1.48	15.20	4.98
Interactions						
N x P						
S.Em ±	0.846	0.279	0.774	0.876	8.978	2.943
C. D. @ 5%	NS	NS	2.27	2.57	NS	NS
N x K						
S.Em ±	0.846	0.279	0.774	0.876	8.978	2.943
C. D. @ 5%	NS	NS	NS	NS	NS	NS
P x K						
S.Em ±	0.690	0.228	0.632	0.715	7.331	2.403
C. D. @ 5%	NS	NS	NS	NS	NS	NS
N x P x K						
S.Em ±	1.196	0.395	1.095	1.239	12.698	4.162
C. D. @ 5%	3.50	1.13	NS	NS	37.24	12.20
C.V.%	6.00	6.45	8.47	7.39	6.90	6.98

Table 2: Interaction effect of NPK on growth parameters

Treatment combinations (kg ha^{-1})	Plant height (cm)	Number of primary branches	Fresh weight of plant (g)	Dry weight of plant (g)
100: 50: 75	27.99	8.33	270.75	83.24
100: 50: 100	34.86	10.09	313.67	101.89
100: 75: 75	34.35	10.12	301.40	92.11
100: 75: 100	33.47	9.59	322.78	102.44
150: 50: 75	33.70	9.20	290.72	87.55
150: 50: 100	35.04	10.89	337.53	109.05
150: 75: 75	34.54	10.19	334.41	109.58
150: 75: 100	35.87	12.56	319.46	109.09
200: 50: 75	35.14	10.63	351.38	110.47
200: 50: 100	34.33	11.48	298.80	105.06
200: 75: 75	36.24	11.08	314.37	111.26
200: 75: 100	38.95	13.14	369.74	117.20
S. Em $\pm$	1.196	0.395	12.698	4.162
C. D. @ 5%	3.50	1.13	37.24	12.20
C. V.%	6.00	6.45	6.90	6.98

Table 3: Interaction effect of NP on plant spread (N-S) and (E-W)

Treatments	Nitrogen levels					
Phosphorus levels	Plant spread (N-S)			Plant spread (E-W)		
	100 kg ha^{-1}	150 kg ha^{-1}	200 kg ha^{-1}	100 kg ha^{-1}	150 kg ha^{-1}	200 kg ha^{-1}
50 kg ha^{-1}	25.25	29.43	28.89	19.45	19.61	23.39
75 kg ha^{-1}	28.97	28.87	32.90	21.74	24.54	25.06
S. Em $\pm$	0.774			0.876		
C. D. @ 5%	2.27			2.57		
C. V.%	8.47			7.39		

The probable reason for good shelf life and vase life might be that nitrogen is necessary for the production of amino acids, which are building blocks of protein. Proteins are important for maintaining the quality and appearance of loose flowers

Effect of phosphorus

Significantly longer vase life and shelf life (6.47 days and 26.59 days) were observed in treatment P_2 (75 kg ha^{-1}). Likewise, the minimum vase life and shelf life (5.58 days and 23.98 days) were observed in treatment P_1 (50 kg ha^{-1}). The reason associated with vase life and shelf life of flower might be that phosphorus help to promote the development and maintenance of healthy flower tissues, leading to longer life of flowers. This result was in close conformity to that of Fayaz *et al.* (2016) [9] in gerbera and Singh *et al.* (2013) [31] in gladiolus, Sendhilnathan and Manivannan (2019) [28] in tuberose and Duggani (2016) [8] in gomphrena.

Effect of potassium

Significantly maximum vase life and shelf life (6.56 days and 26.43 days) was observed in treatment K_2 (100 kg ha^{-1}) whereas minimum vase life (5.92 days and 24.45 days) was found in treatment K_1 (75 kg ha^{-1}). Potassium plays a key role in maintaining turgor pressure in plant cells, essential for maintaining turgidity of cut flowers, which might be the reason that vase life and shelf life are prolonged. These results were in close conformity to that of Fayaz *et al.* (2016) [9] in gerbera and Singh *et al.* (2013) [31] in gladiolus, Sendhilnathan and Manivannan (2019) [28] in tuberose and Duggani (2016) [8] in gomphrena.

Interaction effect of N and K

Vase life and shelf life of gomphrena were significantly maximum (7.05 days and 29.10 days respectively) in treatment combination N_3K_2 (200: 100 kg ha^{-1}) These results were in close conformity to that of Fayaz *et al.* (2016) [9] in gerbera and Singh *et al.* (2013) [31] in gladiolus. The interaction effect of nitrogen and potassium was found to be significant because in terms of flower keeping quality, both these nutrients play an important role. Hence, this combination was found to be ideal for vase life and shelf life of gomphrena.

Table 4: Effect of different levels of NPK on quality parameters

Treatment	Vase life (days)	Shelf life (days)
Nitrogen		
N_1 = 100 kg ha^{-1}	5.58	23.98
N_2 = 150 kg ha^{-1}	6.16	25.33
N_3 = 200 kg ha^{-1}	6.98	27.02
S.Em ±	0.160	0.649
C. D. @ 5%	0.47	1.90
Phosphorus		
P_1 = 50 kg ha^{-1}	6.01	24.30
P_2 = 75 kg ha^{-1}	6.47	26.59
S.Em ±	0.130	0.530
C. D. @ 5%	0.38	1.55
Potassium		
K_1 = 75 kg ha^{-1}	5.92	24.45
K_2 = 100 kg ha^{-1}	6.56	26.43
S.Em ±	0.130	0.530
C. D. @ 5%	0.38	1.55
Interactions		
N x P		
S.Em ±	0.226	0.919
C. D. @ 5%	NS	NS
N x K		
S.Em ±	0.226	0.919
C. D. @ 5%	0.66	2.70
P x K		
S.Em ±	0.184	0.750
C. D. @ 5%	NS	NS
N x P x K		
S.Em ±	0.319	1.300
C. D. @ 5%	NS	NS
C.V.%	8.86	8.85

Table 5: Interaction effect of NK on quality parameters

Treatments	Nitrogen levels					
Potassium levels	Vase life (days)			Shelf life (days)		
	100 kg ha^{-1}	150 kg ha^{-1}	200 kg ha^{-1}	100 kg ha^{-1}	150 kg ha^{-1}	200 kg ha^{-1}
75 kg ha^{-1}	5.35	5.49	6.91	22.12	26.32	24.94
100 kg ha^{-1}	5.81	6.82	7.05	25.85	24.35	29.10
S. Em ±	0.226			0.919		
C. D. @ 5%	0.66			2.70		
C. V.%	8.86			8.85		

Nitrogen uptake

Effect of nitrogen

Significantly maximum nitrogen uptake (3.02 g plant^{-1}) was observed in treatment N_3 (200 kg ha^{-1}) and minimum uptake (1.73 g plant^{-1}) was observed in treatment N_1 (100 kg ha^{-1}). The reason might be that roots absorb either nitrate or ammonium ions. When nitrogen is added into soil, they are available in nitrate form. So, increased urea application make more nitrate ions available in soil, thus increasing nitrogen uptake. This finding was found to be in agreement with Divyashree *et al.* (2021) [7] in gaillardia and Nirgulkar *et al* (2020) [16]. in African marigold.

Effect of phosphorus

Significantly maximum nitrogen uptake (2.48 g plant^{-1}) was found in treatment P_2 (75 kg ha^{-1}) and minimum (2.12 g plant^{-1}) in treatment P_1 (50 kg ha^{-1}). The increase in nitrogen uptake might be due to the reason that phosphorus promotes root growth, root hair formation and mycorrhizal association. This finding was found to be in agreement with Divyashree *et al.* (2021) [7] in gaillardia and Nirgulkar *et al* (2020) [16] in African marigold.

Effect of potassium

Effect of potassium on nitrogen uptake by plant was found to be significant. Significantly maximum nitrogen uptake (2.39 g plant^{-1}) was found in treatment K_2 (100 kg ha^{-1}) and minimum nitrogen uptake (2.21 g plant^{-1}). The increased nitrogen uptake might be due to the reason that potassium helps in maintaining ion balance within the plant cells and influences the uptake of nitrogen and other nutrients. This finding was found to be in agreement with Divyashree *et al.* (2021) [7] in gaillardia and Nirgulkar *et al.* (2020) [16] in African marigold.

Phosphorus uptake

Effect of nitrogen

Significantly maximum phosphorus uptake (0.39 g plant^{-1}) was found in treatment N_3 (200 kg ha^{-1}) and minimum (0.27 g plant^{-1}) in treatment N_1 (100 kg ha^{-1}). This might be due to the reason that adequate nitrogen levels promote healthy root development, thereby increasing the phosphorus uptake. This finding was found to be in agreement with Divyashree *et al.* (2021) [7] in gaillardia.

Effect of phosphorus
Significantly maximum phosphorus uptake (0.37 g plant^{-1}) was found in treatment P_2 (75 kg ha^{-1}) and minimum (0.30 g plant^{-1}) in treatment P_1 (50 kg ha^{-1}). The increase in phosphorus uptake might be due to the reason that phosphorus promotes root growth, root hair formation and mycorrhizal association. This finding was found to be in agreement with Divyashree *et al.* (2021) [7] in gaillardia.

Effect of potassium
Significantly maximum phosphorus uptake (0.36 g plant^{-1}) was found in treatment K_2 (100 kg ha^{-1}) and minimum (0.31 g plant^{-1}) in treatment K_1 (75 kg ha^{-1}). The increased phosphorus uptake might be due to the reason that potassium helps in maintaining ion balance within the plant cells and influences the uptake of phosphorus and other nutrients. This finding was found to be in agreement with Divyashree *et al.* (2021) [7] in gaillardia.

Potassium uptake
Effect of nitrogen
Significantly maximum potassium uptake (2.24 g plant^{-1}) was observed in treatment N_3 (200 kg ha^{-1}) and minimum (1.64 g plant^{-1}) in treatment N_1 (100 kg ha^{-1}). This might be due to the reason that nitrogen stimulates the activity of potassium transporters, which are responsible for uptake of potassium. This finding was found to be in agreement with Divyashree *et al.* (2021) [7] in gaillardia.

Table 6: Effect of different levels of nutrient uptake by plant

Treatment	Nitrogen uptake (g plant^{-1})	Phosphorus uptake (g plant^{-1})	Potassium uptake s (g plant^{-1})
Nitrogen (N)			
N_1 = 100 kg ha^{-1}	1.73	0.27	1.64
N_2 = 150 kg ha^{-1}	2.15	0.35	1.99
N_3 = 200 kg ha^{-1}	3.02	0.39	2.24
S.Em ±	0.062	0.008	0.060
C. D. @ 5%	0.18	0.02	0.17
Phosphorus (P)			
P_1 = 50 kg ha^{-1}	2.12	0.30	1.83
P_2 = 75 kg ha^{-1}	2.48	0.37	2.08
S.Em ±	0.051	0.007	0.049
C. D. @ 5%	0.14	0.02	0.14
Potassium (K)			
K_1 = 75 kg ha^{-1}	2.21	0.31	1.81
K_2 = 100 kg ha^{-1}	2.39	0.36	2.10
S.Em ±	0.051	0.007	0.049
C. D. @ 5%	0.14	0.02	0.14
Interactions			
(N x P)			
S.Em ±	0.088	0.012	0.084
C. D. @ 5%	0.25	NS	NS
(N x K)			
S.Em ±	0.088	0.012	0.084
C. D. @ 5%	NS	NS	NS
(P x K)			
S.Em ±	0.072	0.010	0.069
C. D. @ 5%	NS	NS	NS
(N x P x K)			
S.Em ±	0.125	0.017	0.119
C. D. @ 5%	0.36	0.04	0.34
C.V.%	9.37	8.51	10.53

Effect of phosphorus
Significantly maximum potassium uptake (2.08 g plant^{-1}) was found in treatment P_2 (75 kg ha^{-1}) and minimum (1.83 g plant^{-1}) in treatment P_2 (75 kg ha^{-1}). The increase in potassium uptake might be due to the reason that phosphorus promotes root growth, root hair formation and mycorrhizal association. This finding was found to be in agreement with Divyashree *et al.* (2021) [7] in gaillardia.

Effect of potassium
Significantly maximum potassium uptake (2.10 g plant^{-1}) was found in treatment K_2 (100 kg ha^{-1}) and minimum (1.81 g plant^{-1}) in treatment K_1 (75 kg ha^{-1}). The increased potassium uptake might be due to the reason that potassium helps in maintaining ion balance withihe plant cells and influences the uptake of phosphorus and other nutrients. This finding was found to be in agreement with Divyashree *et al.* (2021) [7] in gaillardia.

Interaction effect of N and P
The interaction effect of N and P on nitrogen uptake by plant was found to be significant. Significantly maximum nitrogen uptake (3.25 g plant^{-1}) was found in treatment combination N_3P_2 (200: 75 kg ha^{-1}). This might be due to the reason that nitrogen and phosphorus in the above levels are ideal for increased nitrogen uptake. This finding was found to be in agreement with Nirgulkar *et al* (2020) [16] in African marigold.

Table 7: Interaction effect of NP on nitrogen uptake by plant

Phosphorus levels	Nitrogen levels		
	Nitrogen uptake (g plant^{-1})		
	100 kg ha^{-1}	150 kg ha^{-1}	200 kg ha^{-1}
50 kg ha^{-1}	1.71	1.85	2.80
75 kg ha^{-1}	1.75	2.46	3.25
S. Em ±	0.088		
C. D. @ 5%	0.25		
C. V. %	9.37		

Table 8: Interaction effect of NPK on nutrient uptake by plant

Treatment combination (kg ha^{-1})	Nitrogen uptake (g plant^{-1})	Phosphorus uptake (g plant^{-1})	Potassium uptake (g plant^{-1})
100: 50: 75	1.53	0.21	1.40
100: 50: 100	1.90	0.29	1.73
100: 75: 75	1.60	0.27	1.51
100: 75: 100	1.89	0.34	1.93
150: 50: 75	1.62	0.25	1.54
150: 50: 100	2.08	0.36	2.17
150: 75: 75	2.47	0.39	2.05
150: 75: 100	2.45	0.39	2.23
200: 50: 75	2.99	0.36	2.15
200: 50: 100	2.62	0.35	2.03
200: 75: 75	3.06	0.40	2.21
200: 75: 100	3.44	0.46	2.57
S. Em ±	0.125	0.017	0.119
C. D. @ 5%	0.36	0.04	0.34
C. V. %	9.37	8.51	10.53

Interaction effect of N, P and K

Significantly maximum nitrogen, phosphorus and potassium uptake (3.44 g plant^{-1}, 0.46 g plant^{-1} and 2.57 g plant^{-1}) was found in treatment combination $N_3P_2K_2$ (200: 75: 100 kg ha^{-1}). This might be due to the reason that nitrogen, phosphorus and potassium in the above levels are ideal for increased nutrient uptake. This finding was found to be in agreement with Divyashree *et al.* (2021) [7] in gaillardia.

Conclusion

Based on the above discussion and results, it can be inferred that the application of 200:75:100 kg ha^{-1} of NPK significantly enhanced various growth parameters, including plant height, number of branches, plant spread (N-S), plant spread (E-W), fresh weight of plant, and dry weight of plant. Additionally, there was a notable improvement in flower-keeping quality, such as vase life and shelf life. Moreover, the nutrient uptake by plants showed favorable outcomes. Therefore, for the successful cultivation of gomphrena, it is recommended to apply 200:75:100 kg ha^{-1} of NPK.

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